THREE TEXTILE RAW MATERIALS AND THEIR MANUFACTURE

INTERNATIONAL ACCEPTANCE BANK, INC.
NEW YORK

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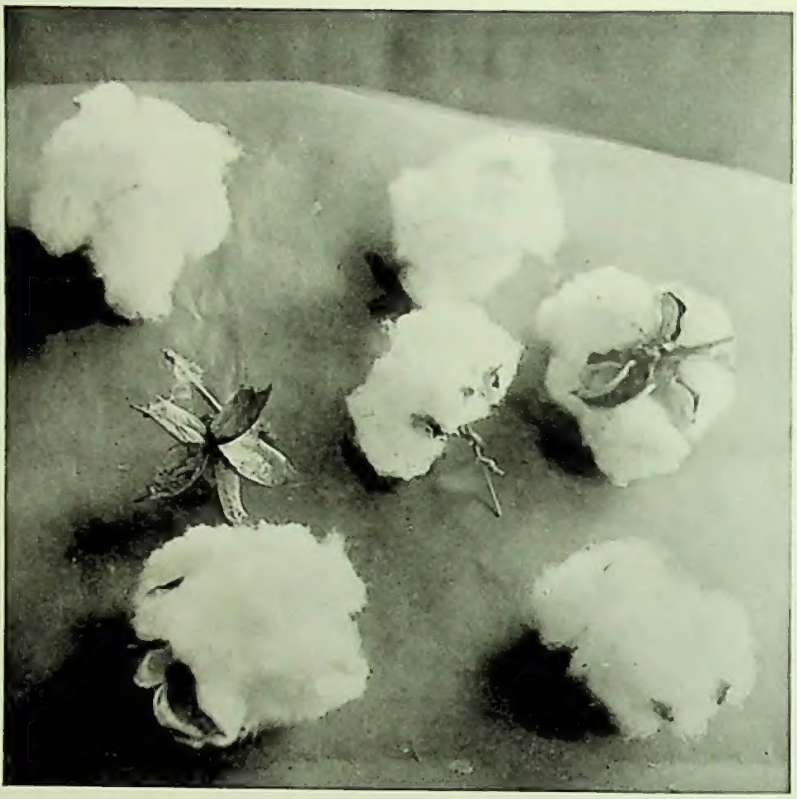


Cotton Bolls

PREFACE

The importance of the three main textiles in the civilized life of today is probably but vaguely realized by the majority of people. In this country we consume raw cotton alone at the rate of about twenty-six pounds per capita each year, which if translated to yards of cloth and other fabric, would make a strip longer than the distance from the earth to the moon, and a yard wide all the way. Add wool and silk to this and the picture becomes even more impressive. There is not a man, woman or child who does not use one or all three of these textiles in daily life. With this in mind we submit this brief description of how they are produced, emphasizing in particular the development of the raw material in each case.

Parts I and II are practically revised editions of "Cotton and Cotton Manufacture" and "Wool and Wool Manufacture" which were written by James Paul Warburg in 1921 and 1920, respectively, and published by the First National Bank of Boston, with whom he was then associated. We take this occasion to acknowledge the extreme courtesy of the First National Bank of Boston in allowing the use of this material. Part III, dealing with Silk, has been newly compiled by Benjamin Strong, Jr., of the International Acceptance Bank, Inc.

No attempt has been made in these studies to enter very deeply into the technical processes involved, the purpose being more to give a condensed outline of the subject from the layman's point of view. While actual survey and observation were extensively made in each case, a great part of the material has of necessity been obtained from standard works on these subjects. In this connection we wish especially to render acknowledgment to Professor M. T. Copeland of Harvard University, whose studies were freely used by the author of Part I on Cotton. In the case of Silk, we are particularly grateful to Mr. W. D. Darby, whose "Silk, The Queen of Fabrics" has been of invaluable assistance. To the many friends in the textile trades who have provided opportunities for first hand observation, as well as a wealth of information, we tender our sincere thanks and grateful appreciation.

INTERNATIONAL ACCEPTANCE BANK, INC.

New York, N. Y., October, 1924.

PART ONE

COTTON

By
James Paul Warburg
Vice-President
International Acceptance Bank, Inc.

Photographs by courtesy of the
Pacific Mills and
Keystone View Co.

Cotton Field

CHAPTER I

THE RAW MATERIAL

1. The Cotton Plant

Derivation of Names

The word, "Cotton", is said to be derived from an Arabic word, "Qutun", originally meaning flax; and the botanical name of the plant, Gossypium, signifying the fleece worn, was first found in the writings of Pliny, and is derived from the Sanskrit. Thus, in the mere origins of the colloquial and scientific designations of the plant, we have ample proof of its antiquity.

Botanical Types

The cotton plant belongs to the mallow family and is a native of the tropics. The genus has a great many botanical varieties, all of which, in the wild state, are perennial, but under cultivation tend to become annual. One variety, Gossypium Arboreum, which is found chiefly in Mexico and Brazil, attains a height of over fifteen feet. This tree cotton, however, has not been extensively cultivated because of the obvious expense of picking. Of the herbaceous varieties the most commonly known are the American and the long-staple Egyptian. G. Barbadense, known as Sea Island cotton, is another long staple variety which is grown only in certain counties of Georgia, South Carolina and Florida.

The Cotton Plant

In all the cultivated species the plant attains a height of two to four feet. The leaves vary, but all have characteristic lobes. The blossoms also vary a good deal in color, but have this in common that the seeds are contained in a pod or boll which is filled with a floss not unlike that of the common milk-weed. In due course the boll bursts, exposing the mass of fluffy fibre from which the plant derives its extraordinary value. The superiority of cotton over other vegetable fibres, such as hemp or flax, is in the natural twist, which makes it inherently adaptable to spinning.

The Fibre

The single fibre consists of a hollow tube having transverse joints at irregular intervals, and this tube, when dry, has a tendency to flatten out and curl. The more of this natural elasticity is found in the fibre the better it is for spinning purposes, and an immature fibre is for this reason unsatisfactory. Cotton is exceedingly susceptible to moisture, and a succession of violent atmospheric changes will cause such a rapid contraction and expansion in its fibre as to destroy its elasticity. From the point of view of the manufacturer there is very little difference between immature cotton and that which has suffered loss of vitality.

Seeds and Stems

Besides yielding a natural wool from which a tremendous number of products are derived, the seed of the plant gives forth a highly useful vegetable oil, and the stems and leaves are used for fodder.

2. History and Distribution

Ancient History

The origin of the cultivation and commercial use of cotton is shrouded in the dim veils of antiquity. The records of India show that the plant was grown, and its fibre utilized, from the earliest times. The Phoenicians and the Hebrews are known to have made cotton clothing, and later the art was transmitted by them to the Greeks and Romans. The vague annals of China indicate a familiarity with this plant and its value extending back to the remote past, and the same is true of Japan. Cortez found a flourishing textile industry among the Aztecs in 1519, and in Peru, Pizarro found cotton garments said to antedate the civilization of the Incas. Again early Portuguese chroniclers relate the discovery of native cotton in Brazil.

Europe

The Arabs and Saracens were largely responsible for the introduction of the textile industries to western Europe in the ninth century, but it was not until about the middle of the seventeenth century that any great progress was made. During this time the British began to attempt the cultivation of cotton in their colonies, and it was about 1650 when the first Virginia plantations were begun. Since that time the United States has forged ahead until at present it grows over three-fifths of the world's crop.

America

Egypt

The cultivation of cotton in Egypt was begun about 1821, American Sea Island seeds being imported at that time. The fertile alluvial soil of the Nile delta was found particularly adapted to this use, and extensive irrigation later expanded the area. The construction of the Great Assouan Dam late in the nineteenth century gave a tremendous impetus to the industry. Egyptian cotton is mostly of the long staple variety, the best, known as Sakellarides, averaging an inch and three-quarters.

India

Cotton culture in India is perhaps the oldest of all, but Indian cotton is of the short staple variety, and can only be used by certain manufacturers most of which are located in Japan and Germany. About twenty-five million acres are said to be under cultivation, but statistics are very meagre.

China

China has long been a large grower of cotton, but the native species are of a harsh, short fibre. Korea and the Yangtze and Wei basins are the chief sources, and American cotton has recently been introduced in the southern provinces.

Other Countries

Russia began to raise American cotton on a large scale in Turkestan only some twenty years ago, and bids fair to become a large producer. The plant is indigenous to almost all the Central and South American countries, and particularly in Mexico, Brazil and Peru, it has great potentialities. Peru has two kinds of native cotton known as the rough

and smooth varieties. The former is of a very long and tough fibre and is valuable because it can be blended with wool.

American Varieties

The greatest part of the American crop consists of the Upland variety, although, as we have noted, there is a small but important crop of Sea Island in the Southern Atlantic states. Another long staple species, known as Pimas, has recently been introduced in Arizona, and the alluvial soil of Mississippi, Arkansas, and Louisiana has produced still other desirable species, locally known as "Rivers," "Peelers," and "Benders." Before we consider the relative manufacturing merits of the various kinds of cotton, it would perhaps be well to consider briefly how the crop is grown.

3. Cultivation

Growth of the plant

The cotton season of course varies in different latitudes, but the planting is done everywhere in the early spring months. The proper care and fertilization of the soil and its preparation to receive the seed is of the utmost importance. The plant ripens in about four months, so that the picking season in this country usually begins in August, and continues until the first killing frost. From the time of the opening of the first bolls the cotton continues to grow, unless killed by drought or insects, until the cold puts a stop to vegetation, and the same stalk frequently contains ripe and immature cotton at the same time. The cotton which matures first and has been least exposed to weather when picked is likely to be freer of spots and discolorations than that which is picked at the end of the season.

Enemies of the plant

The two great enemies of the cotton plant are drought and insect depredations. Late frosts and the right quantity of rain and sunshine are what every cotton planter prays for, and praying is about all he can do in this respect. Not so, however, with insects. Unfortunately there are a great number of rapacious little creatures rendered particularly hardy by some caprice of Nature, to whom the growing cotton plant represents an especial delicacy. Against them the planters, under the guidance of the Department of Agriculture, are waging continuous warfare. It is said that insect depredation, at pre-war prices cost the country an annual sum of $60,000,000, more than half of which is attributable to the two worst offenders, the boll weevil and the boll worm. Coming in hordes across the Mexican border, the boll weevil has destroyed millions of bales of cotton annually, and as yet no very effective remedy has been found to exterminate it.

The Boll Weevil

Even at that, however, the planter's greatest worry is perhaps not so much the growth as the harvesting of his crop. To get his cotton picked

rapidly and properly, an operation for which no successful machinery has yet been devised, and to have it properly ginned, presents his chief problem. If cotton is left too long on the stem it will be exposed to the detrimental effects of the weather. Coloring matter from the newly opened bolls, or from the soil, is washed into the floss by the rain, and while such spots or stains may be bleached out by the sun, the lustrous bloom never returns. Frost will make permanent tinges or stains, and the wind will frequently wrap the pendulous locks of fibre-covered seed about the stems of the plant or tangle them up in the leaves.

Weather Defects

When the pickers do not exercise proper care stem and leaves frequently get picked along with cotton, and a considerable quantity of dirt inevitably finds its way into their bags. Or else the cotton may be picked when it is damp, with the result that the teeth of the gin, instead of picking out the seeds and stems will cut the matted fibres, producing a class of cotton known as "Gin-cut". Moreover the gin brushes will be unable to separate the matted tufts, and so they go into the bale as "naps" or "neps". All these factors militate against the planter in his efforts to have his crop classified as high as possible.

Careless Picking

Bad Ginning

4. Grades and Staples

Grades Based on Condition

The classification of cotton into the standard grades fixed by the Government constitutes an exceedingly difficult art. There is absolutely no mechanical basis, and the classification is a purely relative one. The kind of plant has no bearing whatsoever, nor has the length or strength of staple. It is really a distinction based upon the condition of the cotton, rather than upon its inherent attributes.

The grade "MIDDLING" is the basis upon which the market values of the other grades are quoted. There are eight full grades:

The Full Grades

Fair	*Low Middling*
Middling Fair	*Good Ordinary*
Good Middling	*Ordinary*
Middling	*Low Ordinary*

Tinges and Stains

"Points"

Between these full grades are the half grades, known as the Stricts, and some classers use quarter grades with which, however, we shall not concern ourselves here. The grades and half-grades are quoted for whites, tinges, and stains. A stain is a heavy discoloration while a tinge is a lighter hue, and partial discolorations, known as spots, are permissible in the lower grades of whites. The values of the various grades are always quoted as so many points on or off White Middling, a point being 1/100th. of a cent. Thus, if Middling White were quoted at 24c

and Ordinary as 300 points off, it would mean that Ordinary was worth 21c. An example is given below of a regular quotation sheet.

U. S. Grades	*White	**Tinges	**Stains
Middling Fair	403 on	Nominal	Nominal
Strict Good Middling	328 on	49 off a	Nominal
Good Middling	253 on	152 off a	447 off a
Strict Middling	135 on	300 off a	618 off a
Middling	Basis	456 off a	809 off a
St. Low Middling	305 off	704 off a	Nominal
Low Middling	843 off	1064 off a	Nominal
Strict Good Ordinary	1230 off	Nominal	Nominal
Good Ordinary	1518 off	Nominal	Nominal

*U. S. Government differences.

**Average of differences on New York, New Orleans, Memphis and either the Savannah or the Augusta exchanges.

The Human Element

It is obvious that in this classification the human element plays a great part. The difference between quarter grades, or even half grades, or between a tinge and a stain, are subject to a great variety of interpretations. While there is no definite standard, Middling must be cream or white, must show no soil evidence, no gin-cuts or naps, may have a few pieces of leaf (not powdered), and a few motes, (immature seeds). As the grades go up the cotton must be freer of impurities until the top grades have to show practically a perfect lustrous, silky, white, and clear fibre. On the lower side the impurities increase, until, in the Ordinaries, we find large and small leaf particles, sticks, hulls, dirt, sand naps, gin-cuts, and spots, together with a dingy color.

Proportion of Impurities

Some Cottons not Sold on Middling Basis

It is this classification that governs the trading on all the exchanges, and upon which the planter originally sells his crop. The exceptions are those varieties of cotton which are distinct from the crop as a whole. Sea Islands are sold as Fancy, Choice, Fine, Medium, and Common. Bolly or immature cotton is sold by separate agreements; and Linters, the fibres regained by the seed mills from reginning the seed, are not sold on this basis. Neither is what is known as the "City Crop" of loose cotton accumulated from taking samples, sold in this way.

Staple Length

Aside from grade there are two other qualifications which are of equal importance to the manufacturer: length, and strength. Lengths are quoted in eights of an inch, and cotton under 1⅛" is termed short, while that over 1⅛" is long. The normal lengths run from ¾" to 1⅞", and it is noteworthy that, where a normal difference between grades would be 25 points, the difference of ⅛" would be about 250 points. "Pulling" for staple is another art where the individual's judgment plays an important part.

Elasticity

Strength.—elasticity and tensile strength.—is again one of the mill's prerequisites. The usual buyer's test for fibre vitality is to compress a sample in the hand to see if it will return to its former shape. The importance of length is that it governs the fineness of the yarn to be spun, while grades affect the finish of the cloth. We shall see later that mills cannot buy mixed lots, but must have even-running grades of fixed staple.

5. Buyers of Raw Cotton

Storekeepers as Local Buyers

The small planters of the South are usually unable to finance themselves independently through the growing and picking seasons. Consequently the local store-keeper, from whom the planters buy their supplies, usually extends credit in the form of an open account and so becomes the first middleman. Not infrequently the store-keeper will accept cotton rather than money in settlement of his accounts, and where he follows this practice he becomes what is known as a local buyer. When he has accumulated sufficient cotton he sells either to an intermediate buyer, or to the buyer for some merchant or mill.

Large Growers

In the case of the larger grower, or the syndicate of growers, the local buyer is usually eliminated. These planters obtain their credit from the large merchant buyers, who in turn are carried by their banks.

Intermediate Buyers

Very frequently the local buyers are scattered so thickly through a neighborhood, and each accumulate such small and heterogeneous lots of cotton that an intermediate buyer finds his way into the natural order. Sometimes the intermediate is merely a "scalper" who buys from the local dealer and sells to merchant buyers. In other cases, notably in Texas, he acts as a concentrating agent, buying at local points from growers and selling, usually at compress points, to representatives of merchants or mills. In the latter case he is referred to as a "street buyer."

Financing Early Stages

Where the grower surrenders his cotton to the local dealer the latter usually has it ginned, but in cases where the planter is able to finance himself he takes his cotton to the gin himself, pays for the ginning, and either sells in so-called gin bales. (before they are compressed) or, if a warehouse is available at the gin or compress point, holds his cotton until he can obtain a satisfactory price for it. The local banks perform a very important part of the crop financing at this stage, for, since the grower sells for cash, the buyers require advances. These are made by the Southern banks against buyers' tickets, showing cotton purchased, against gin receipts, warehouse receipts, compress receipts, and finally when the cotton is shipped, against bills of lading.

The Square Bale

The Merchant Buyer's Importance

The large cotton merchants fulfill a very essential function in that they are responsible for the concentration of the raw material and for its redistribution into the proper channels of manufacture. They maintain branches and representatives throughout the entire cotton growing areas and are directly connected by wire with all the important exchanges. By far the bulk of their buying is done after the close of the New York Exchange from local and intermediate buyers who during the day have been acquiring mixed lots of all sorts. The merchant's representative, known as the take-up man, goes over and classifies the cotton accumulated by the local buyers, takes a sample from each bale which he tags with a duplicate of the shipping tag he places on the bale itself,

The Take-up Man

and then ships the cotton to the concentration point and the samples to the office at that place. He pays the local buyer by draft or check.

Even-running Lots from Compress Point

The office at the concentration point, usually where there is a compress, has in the meantime received instructions from the head office as to how to make up the various lots. As the bales are compressed they are collected into even-running lots of certain grades for which the head office has received inquiries from mills, and are shipped out in this way. The branch office will ship according to instructions forwarding the bills of lading with invoices and sight drafts to the head office or to some bank.

Cooperative Marketing

Since the war, and particularly in the last three years, the co-operative movement has in some sections developed to such an extent as to supplant in large part the old system of marketing. In Texas, Georgia, and other States, a large part of the crop is now concentrated, financed, and sold through these extensive organizations of growers either direct to mills, or to large merchants and exporters.

Almost all cotton is bought on Middling Basis, but some is taken on sample with guarantees, (often a dangerous practice for both parties), and some is taken at a fixed price per bale.

Direct Buying

A few Southern mills buy direct from nearby growers, but the preponderant majority and practically all the Northern mills obtain their cotton through merchants, or through brokers representing Southern merchants.

We have seen briefly how the cotton is grown and brought to market, but we have still to consider the all important question of what determines the price at which it changes hands.

6. The Cotton Exchanges

"Spot" and "Futures"

Cotton trading falls roughly into two categories: trading in cotton for immediate delivery, or spot cotton; and buying or selling for delivery at some future time. Purchases or sales of spot cotton mean that cotton actually will be delivered from vendor to purchaser, but, as we shall see, trading in futures does not necessarily mean that the contract will be fulfilled by delivery. The great cotton markets are New York, Liverpool, New Orleans, Bremen, and Havre. Of these New York is almost entirely a futures market, while New Orleans is chiefly a spot market. Liverpool, Bremen, and Havre trade in both spot and futures, but Liverpool is the European centre for trading in future contracts.

The Great Markets

The New York Cotton Exchange

Only about 2% of the annual crop is sold spot in New York, and yet it is the prices on the New York Cotton Exchange which govern very largely the price paid to the grower in the South by the various buyers.

The New York Exchange is the barometer of the American, and to a large extent, of the world's cotton trade, because its mechanism works out the equilibrium between demand and supply; and as this mechanism consists chiefly of the trading device called the "Hedge", we shall digress for a moment to consider its operation.

The "Hedge"

We might say that hedging is an insurance against fluctuations in cotton prices by purchase or sale of future contracts for cotton against sale or purchase made for actual delivery. It consists of nothing more than of neutralizing the gain or loss which will result from existing delivery contracts if the price rises or falls before delivery date, by creating an off-setting loss or gain.

As Used by the Merchant

Assume, for instance, that a merchant makes a contract with a mill in July for 100 bales October delivery. He sells at the current price of let us say 30 cents per pound plus his overhead and profit. In due course he will obtain his cotton from the South, but in the meantime he covers, or hedges his contract by buying 100 bales of October futures on the Exchange. If he has to pay the grower 31 cents for the cotton which he has sold to the mill for 30 cents, he will on the other hand, be able to sell his future contract which he bought at 30 cents for 31 cents, so that the loss on one is neutralized by the gain on the other. Vice versa, he will lose whatever *extra* profit he might have made from a falling price.

By the Manufacturer

In the same way a manufacturer may buy futures against orders he has accepted for goods, based on the price he expects to pay for his cotton. Or he may sell futures to protect himself on cotton he has bought but has not yet covered by cloth contracts. Hedging by manufacturers, however, particularly in the North, is not a common practice, because the cloth market is not elastic enough to follow accurately in the wake of cotton prices, and also because the mill treasurer rarely wants to hedge cotton in his warehouse, preferring to rely on his own judgment in matters of purchase.

By the Grower

Occasionally a grower may find it to his advantage to hedge his crop. If, for example, he is satisfied in August that the present price for December is likely to be higher than he will obtain later, he may sell December futures for a conservative percentage of his crop, thereby guaranteeing himself against a drop.

Speculation

By far the greatest part of the future trading, however, is done by merchants, because they are actually engaged in the business of selling cotton which they have not yet acquired or of carrying cotton for which they have no contracts. Speculation, of course, enters into the dealings on the exchanges as an important economic factor, in normal times tending to stabilize by discounting future trends, but in periods of extraordinary demand or supply frequently causing violent fluctuations in

prices. At such times there is always a good deal of agitation for preventive legislation, but it is unlikely that dealing in futures will ever be prohibited by law. The present regulations of the large exchanges eliminate abuse as far as possible, and the futures markets are really a factor of safety for the entire industry.

The Dissemination of Quotations

All the large merchants, as we have seen, have branch offices in the South, and all these offices have wire connections with the chief markets. On the basis of the Liverpool quotations and the New York opening prices the head offices will send out to their branches and representatives their daily limits, above which they are instructed not to buy. Inasmuch as most of the small growers are dependent for their news of the markets upon the buyers, they are at somewhat of a disadvantage, but the keenness of competition prevents their exploitation by unscrupulous buyers.

New York Cotton Contract

A contract on the New York Cotton Exchange calling for the delivery of 100 bales specifies Middling grade, but the seller may deliver any grades which are tenderable by the Exchange regulations. These grades are from Strict Low Middling to Middling Fair, but if tinged, not below Middling Tinged. Stains are not tenderable. The grades are determined and settlement made on the basis of so many points on or off Middling, which, as we have seen, is the basis for all quotations.

Buying Season

It is evident that mills, which require certain even-running grades, could of course never buy their cotton on the Middling basis. For this reason, except in the few cases where they buy direct from the growers, mills purchase their requirements from dealers on the basis of samples. Selling to mills, as opposed to selling M/B, is known as selling on merit. Mills usually begin to buy in September and fill about 60% of their year's requirements by January. Those manufacturers who use the high grades usually buy earliest because of the limited crop from which they must obtain their share. Cotton is ordinarily shipped soon after purchase and stored not by the merchant but at the mill. The recent growth of Southern warehouse companies, however, has caused mills to carry less cotton than formerly. Mills ordinarily pay for their cotton in three days.

We have now traced rapidly how the cotton is grown and marketed, and our next concern will be to follow what happens to it during the process of making it into goods. Deferring for the moment consideration of cotton export from the United States, we shall proceed in Chapter Two, to glance at the various aspects of Cotton Manufacture.

CHAPTER II

THE MANUFACTURE OF COTTON

1. History in the U. S.

Much has been written on the subject of the textile industry and perhaps even more still remains to be said. It is not the object of this brief survey to present a complete picture of all the stages of manufacture, but rather to place briefly before the reader a necessarily kaleidoscopic view of the various processes.

Slater's Mills

Whitney's Gin

Although the first cotton mill in the United States was founded in Rhode Island by Samuel Slater in 1790, Whitney's invention of the cotton gin in 1793 marked the real beginning of the cotton growing and manufacturing industries in this country, because it solved the hitherto vexatious problem of separating the fibre from the seed. Nevertheless, until the war of 1812, this country exported almost all of its cotton to Great Britain, and imported from there its cotton goods. The war stimulated the textile industry for two reasons: first, because no British goods were available; and second, because it brought about the transference of New England capital from ships and commerce to home manufacturing industries. The census figures for 1805 show 4,500 spindles in the country; in 1825 there were 800,000.

Stimulus of War of 1812

Growth to 1860

Various inventions, notably Lowell's power loom in 1814, and Jenck's ring spindle in 1830, made it possible for the New England manufacturer to compete with the skilled labor of England, and up to the time of the Civil War the industry made rapid strides. In 1831 795 establishments with 1,200,000 spindles used 77,800,000 pounds of cotton and manufactured $32,000,000 worth of goods. Thirty years later there were 1091 mills with 5,200,000 spindles using 422,700,000 pounds of cotton and making a product worth $115,700,000. At this time 570 of the mills were in New England, 340 in the Middle Atlantic States, 159 in the South, and 22 in the Western States. The New England mills, however, averaged twice as many spindles as the others, and Massachusetts and Rhode Island alone contained 48% of the total.

Civil War

Home industries at this time supplied most of the coarse drills and sheetings, while the fine goods were imported from England. There was a small export trade of coarse goods to Asia. The Civil War cut off the industrial centers from their raw material so that for five years no progress was made, and when normal life was resumed a new tendency towards concentration became manifest. From then on the number of plants decreased and the individual establishment grew larger, so that

in 1880 there were fewer mills and four and one-half times as many spindles as twenty years before.

Rapid Industrial Rise of the South

While we shall discuss the geographical distribution of the industry in a later chapter, it is worthy of note here that the feature of the period beginning about 1880 and extending to the present time, was the gradual growth of the spinning and weaving industry in the South. The social and economic system in the Southern states before the abolition of slavery made those states entirely agrarian, but as soon as a recovery from the war was accomplished, manufacturing, and particularly cotton manufacturing, grew up surprisingly fast. A glance at the growth in spindlage in the United States from 1880 to 1923 will suffice to illustrate. Sixty per cent. of the increase since 1880 was in the South. The units represent millions of spindles.

	1880	1890	1900	1910	1923	Inc. 43 yrs.
North	10.1	12.6	14.5	17.4	19.9	9.8
South	.5	1.7	4.5	11.2	16.3	15.8

2. Making Cotton Yarn

The Bale

Almost all cotton comes to the mill in standard compress bales of five hundred pounds gross. The cotton is condensed to about 22 pounds per cubic foot at the compress, wrapped in coarse jute bagging, and circled with iron hoops. For some time there has been a movement to improve the so-called square bale, or to replace it with a different form of packing. Sea Island cotton is frequently packed in a smaller round bale, and there is much to be said for this practice. What we are concerned with here, however, is that the mill receives the cotton in a compressed form which must be loosened before anything can be done with it.

The Bale-Breaker

Accordingly, the first thing that happens is that the hoops are cut, the bagging removed, and the cotton thrown by hand into the feed-apron of the bale-breaker. This machine does nothing more than to pick the compressed cotton apart and deliver it in tufts about the size of a handfull on a belt conveyor.

The Opener

The travelling belt or feeder delivers these bunches of cotton into machines called Openers, which simply repeat the operation of the bale-breaker on a more thorough scale, reducing the large tufts into many smaller ones. These small pieces are dropped into an air chute and drawn along parallel rods up to the picker room. During transit in the trunk much of the heavier dirt falls between the rods and is removed.

In the most recent installations larger bale-breakers are used which reduce the cotton to small tufts and deliver through an air pipe to a

Bale Breakers

condenser in the picker-room. The condenser either empties into bins or else on to the automatic feed of the breaker-pickers.

As the tufts come out of the chute they fall into the first of three machines known as Pickers, whose function is to beat out the coarser impurities and deliver the cotton in rolls of batting called laps. In the first, or breaker-picker the tufts are thoroughly whirled and pounded over grid-bars by rollers armed with short flail-like projections, and then compressed into a continuous sheet or lap of a given weight per yard, which is wound on a large spool and delivered to the second, or intermediate picker. This machine practically repeats the operation only that

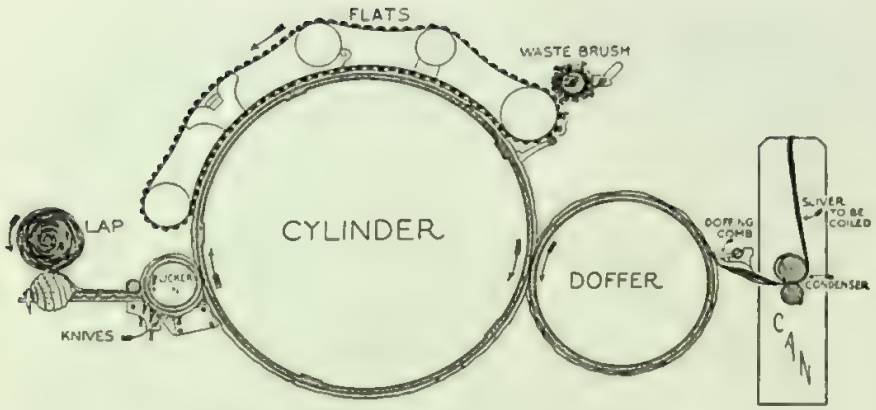
Pickers Remove Coarse Dirt

Picker Room

it combines four laps from the first picker into one which it hands over to the last, or finisher picker. The latter again takes four intermediate laps and forms them into one sheet of fairly clean cotton, containing very little dirt or seed, but still fairly filled with small particles of leaf. In these preliminary operations the cotton has lost about five per cent. of its weight.

The Function of the Card

Before anything else can be done it is now necessary to remove the leaf particles, and to separate the individual fibres from their matted position. Both these functions are performed by the machine known as the Card, the principle of which is that of two surfaces armed with fine wire teeth revolving not quite tangent to each other. Originally carding



PRINCIPLE OF THE FLAT CARD

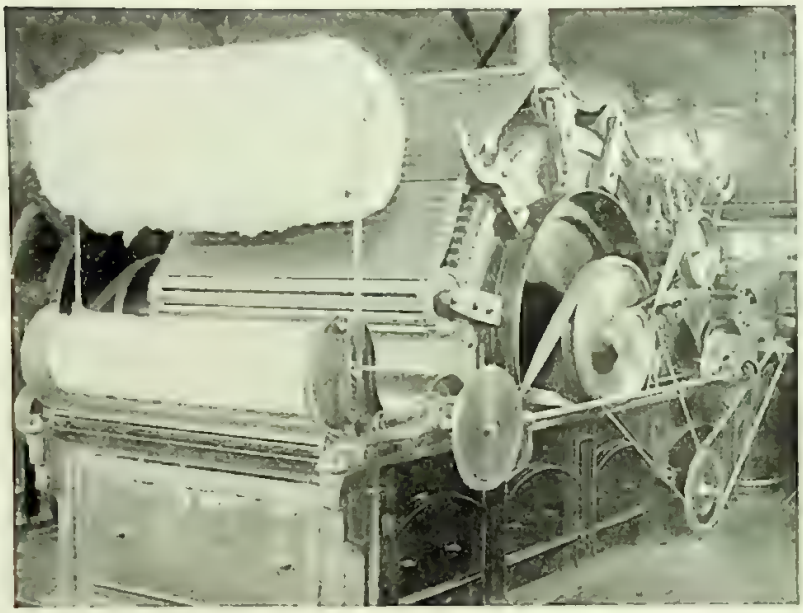
was performed by hand, but the Wellman carding machine was one of the earliest textile inventions. This was considerably improved by the revolving flat card in 1857, the operation of which is somewhat as follows.

Its Operation

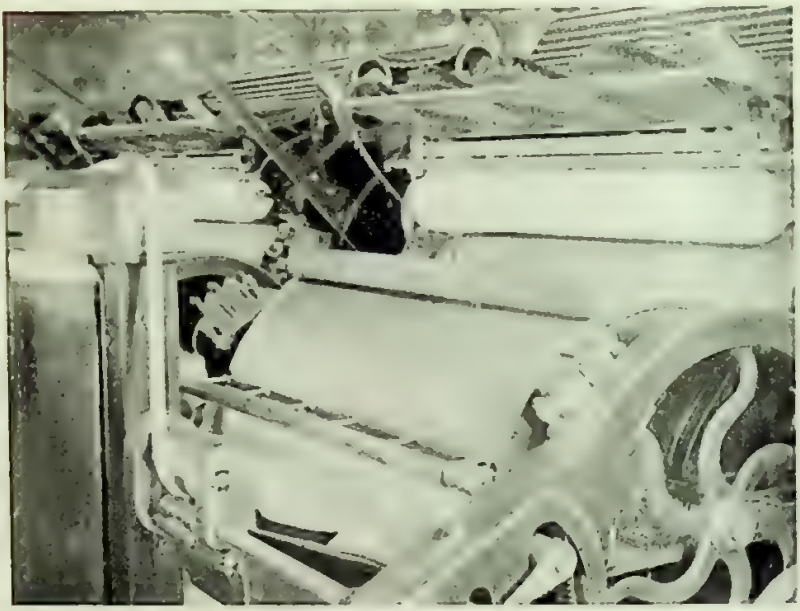
The lap from the finisher picker is fed over a plate on to a revolving cylinder bearing wire teeth, which combs it over a set of knives, thereby removing coarse dirt, and passes it on to a large cylinder armed with millions of fine wire teeth. The latter carries the cotton past a slowly revolving endless chain of flats which remove the neps and fine dirt. The clean, separated fibres are then picked off the cylinder by a smaller rapidly revolving roller called the doffer, which carries them in a filmy sheet to be in turn removed by the doffing comb. The latter, working so rapidly that the eye fails to see it, lifts the sheet of fibres clear so that it may be passed through a funnel and condensed into a single untwisted rope a little under an inch in diameter. This rope is called a sliver, and is automatically coiled into a can like an umbrella-stand.

Counts of Yarn

We have now for the first time reduced the raw material to a continuous strand, comparatively free from impurities. Up to this point, no matter what kind of yarn is to be spun, the operations are practically identical, but from here on the processes vary according to the product desired. A hank of yarn is 840 yards (not to be confused with the



Feed End of Card. Lap Entering



Delivery of Sliver

Drawing

worsted hank of 560 yards) and the number of hanks it takes to make a pound is the basis upon which yarn is classified. Thus a coarse yarn which weighs only twenty hanks to the pound, would be called 20s, while 80s would be a very fine yarn. Various fabrics require different grades of yarn, just as different finenesses of yarn must be spun from varying grades of cotton. The processes preparatory to spinning vary, not only with the counts to be spun, but with the use to which the yarn is to be put. Ordinary coarse and medium yarns for weaving usually follow one process, while fine counts for weaving, or knitting yarn, or coarse yarn made from long-staple cotton such as that used for tire-duck, go through a different preparation. The former are simply drawn and reduced, while the latter are in addition combed.

Two Processes

In the ordinary process, which is by far the most commonly used, the sliver from the card is put through successive similar operations, known

First Process

Roving Frame

Drawing

as drawing, the object of which is to draw out the fibres and cause them to lie parallel to each other. Six card slivers are fed together between two pairs of rollers, the second of which is revolving faster than the first. The obvious result of this is the stretching of that portion of the slivers which is between the two sets of rollers. The operation is usually performed two or three times, in each case combining six strands into one. The sliver delivered by the third drawing machine will be of the same diameter as the original card sliver, but will contain more or less parallel fibres.

Roving Operations

There remains now only one series of operations before the yarn is ready to be spun. The sliver must be reduced in size and given a certain

Four Stages of Roving

amount of twist; these objects are accomplished by the roving frames, of which there are either three or four. The first, or slubber, passes the drawn sliver through rollers without combining, and winds it up on bobbins set in spindles. The sliver is twisted by being fed onto the bobbin by an arm, or flyer, which revolves a little more slowly than the spindle, being drawn around after it. The result is a slightly twisted sliver, now called a roving, about the diameter of a clothes-line. *Slubber*

The intermediate, fine frame, and jack frame,—or, if there are only three roving boxes, the intermediate and fine frames,—combine two rovings into one of smaller size and more twist. The mechanism is much the same, except that in each successive frame the spindles are smaller and revolve faster, until finally the thread is small enough to spin.

Second Process

Where it is desired to spin special kinds or very fine yarns twenty card slivers are usually combined in a machine similar to a drawing frame and known as a sliver-lapper. The twenty ends are drawn between rollers and delivered not as we should expect in one strand, but in a narrow band or lap, which is wound on spools. Four of these laps are again combined and drawn over a spiral surface in the ribbon lapper which delivers its product to the comb. The cotton is now in a band less than a foot wide, with fibres more or less parallel and practically clean. Since it is desired to spin a yarn which demands not only parallel but uniform fibres, the short fibres must be eliminated.

Lapper

The Comb

There are a considerable number of combing machines in use at the present time, but their differences are mechanical rather than in the function they perform. The Heilmann principle is the most commonly used in this country. Eight rolls from the ribbon-lapper are placed in separate rests, or heads, end to end, and each lap is fed through rollers between teeth of a very fine and rapidly oscillating steel comb. Every back and forth motion, known as a nip, delivers about half an inch of filmy sheet from which the short fibres have been combed out. The eight combed sheets are then once more condensed into a single sliver and coiled into a cylindrical can.

Drawing

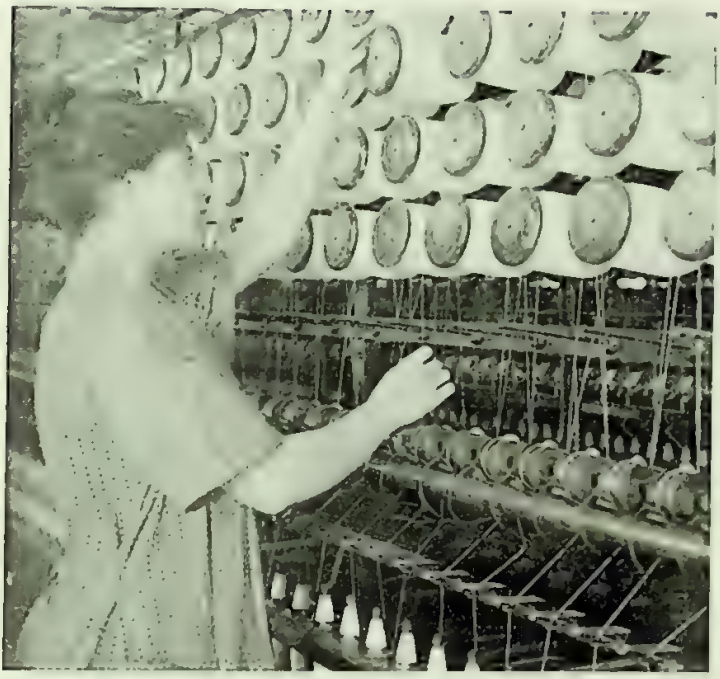
Following the comb there are usually two drawing frames, each combining six slivers into one, and these are followed by the three or four roving frames as in the other process. In the ordinary process the last roving as it leaves the jack frame has been doubled 27,648 times; in the combed yarn there are 2,959.120 doublings before spinning begins.

Doublings

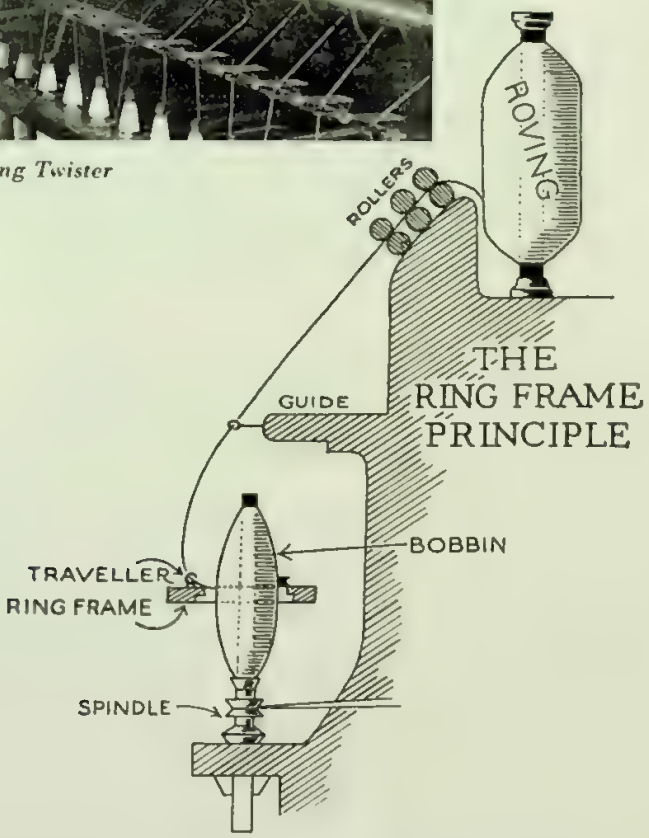
Spinning proper is done either on the mule or the ring spindle. Very little cotton is spun on mules in this country, although mules are extensively used in Europe. We shall concern ourselves here only with the ring spindle, and that in bare outline. (See also Part Two, Page 83).

The Ring Frame

The principle of the ring frame is very similar to that of the roving operations which immediately precede it. The thread is again drawn through two or three sets of rollers running at successively higher rates of speed, and then passes as shown on the accompanying sketch through a guide to a small metal loop, called the traveller, which runs around on a metal track or ring within which the spindle with its bobbin is revolving. Since the spindle pulls the traveller around after it, the yarn is twisted or spun as it is wound on the bobbin. Sometimes two spools of roving are spun into a single thread, but more frequently there is no combination. All the rings on one frame, usually about 256, are moved up and down together on their spindles, so that yarn will be wound evenly on the bobbin.



Ring Twister



Yarn of Filling Bobbin, Warp Bobbin, and Spool

Warp and Filling Bobbins

Not only is a different bobbin used for spinning warp and filling yarns, but they are also wound differently on the bobbin. Warp yarn is wound evenly up and down the whole length of the bobbin, while the filling bobbins, which go straight from the spindle into the shuttle of the loom, are wound on in sections to facilitate rapid unwinding.

Twisting

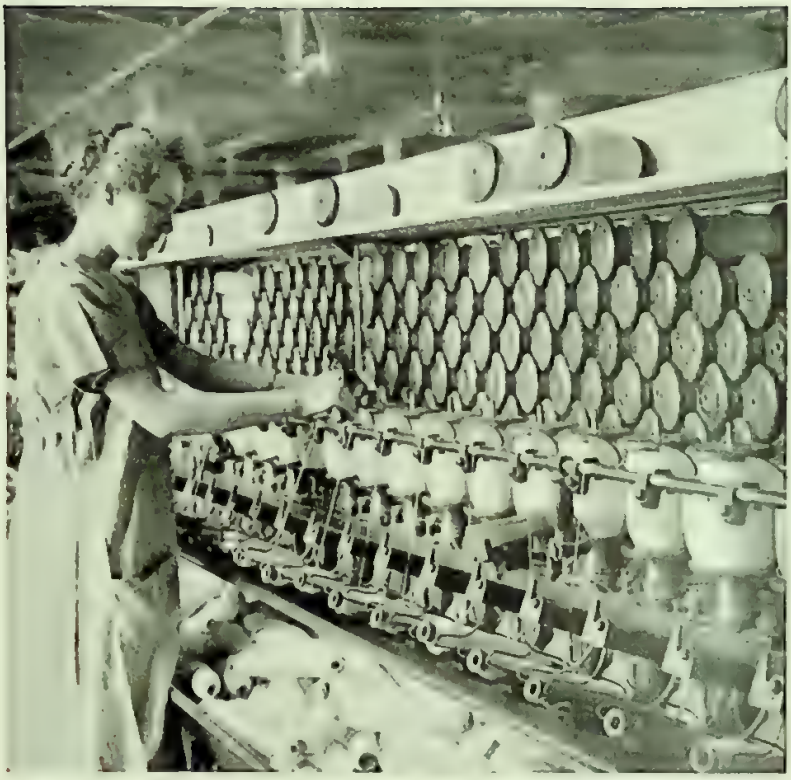
We have now proceeded as far as the finished yarn. Sometimes, however, when a particularly strong thread is desired, or in case of fancy designs, it is desirable to twist two or more threads of yarn together, this being known as two-ply, three-ply, etc. Various effects are obtained by twisting different yarns together, and sometimes worsted and cotton strands are twisted together. The operation is done on a frame similar to the spinning frame.

The Barber Knotter

In these and subsequent operations the Barber Knotter, a little device worn on the hand of the operative, has enormously increased efficiency. By a single motion an entirely unskilled girl can knot and cut off evenly the ends of two threads. *The Barber Knotter*

3. Weaving Gray Goods

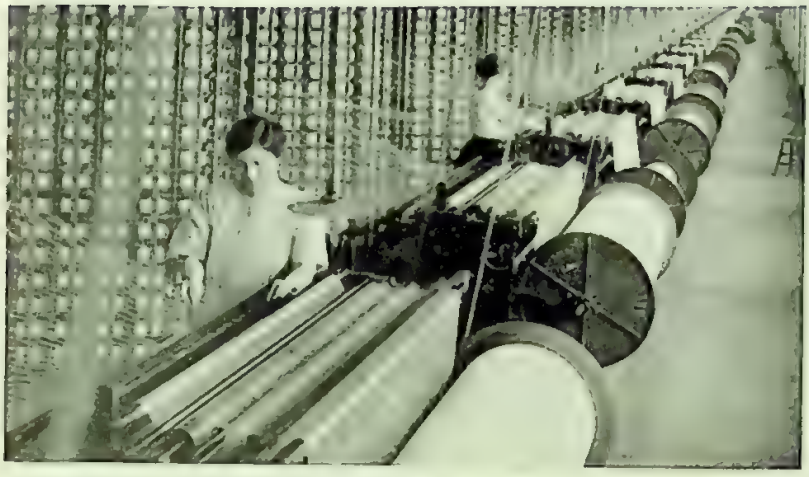
The modern power loom represents one of the most remarkable achievements of industrial development. Into its perfection have gone the inventions and improvements of centuries, and volumes could, and *Principle of Weaving*



Spooling

have been written on the subject of modern weaving. Nevertheless, the old-fashioned hand-loom has not yet gone out of existence, and still finds its use in the development of new designs.

Weaving is, of course, the process whereby yarn is made into cloth, and its fundamental principle is that of the warp and weft structure. In its simplest form this means that a series of threads are stretched parallel to each other, thereby forming a warp. A second thread, called the weft, is then passed over the odd and under the even warp threads, and back again under the odd and over the even. In this way a cloth fabric will gradually be built up. In most cases the process has become considerably more complicated than this, but there are even now certain ma-



The Creels

terials, such as calico, which retain the elementary weave. The actual weaving, that is, the passing of the shuttle carrying the weft thread over and under the warp threads, has now been reduced to an entirely automatic process, even with the most complicated designs, but the preparatory work still entails a large proportion of hand labor.

Spooling

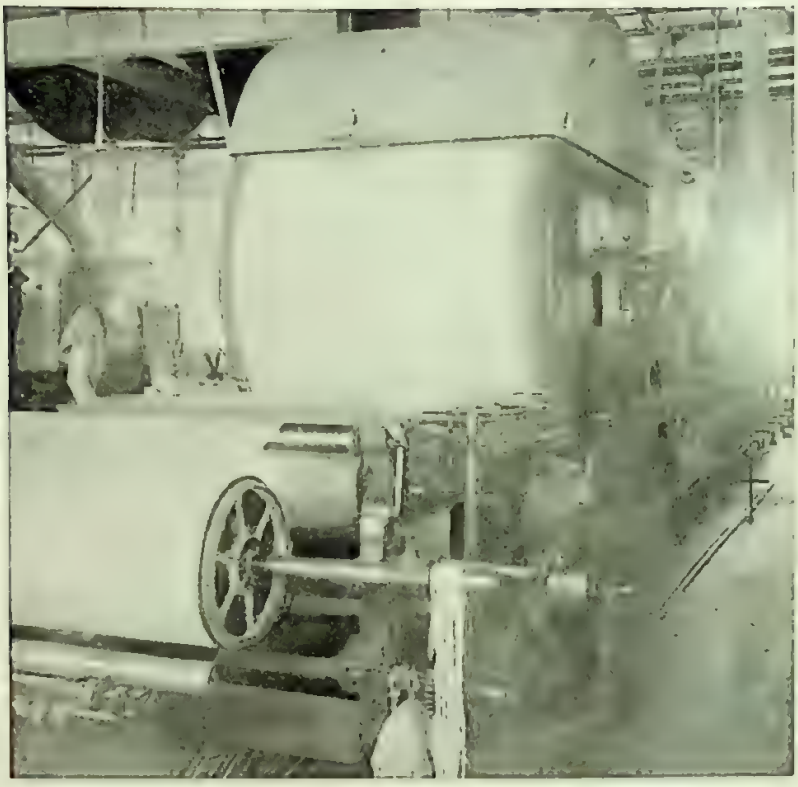
The first operation consists of winding the yarn from the bobbin on to spools, each containing the same length of yarn. This must be done with care or considerable waste will result.

The Creel

The next step is to place these spools in a rack or creel where they fit on glass bearings so that they may be arranged in the proper order and run through the warper on to the section beam. The latter is a large roller several of which are combined to form a beam. The beam is the name given to the roller which is placed in the loom to deliver the warp threads.

Sizing

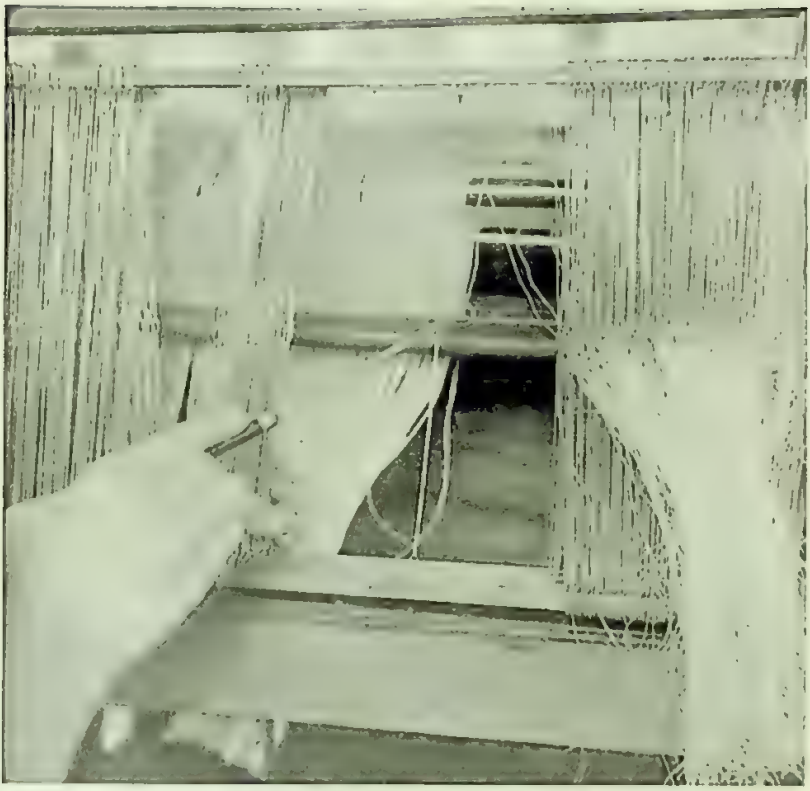
In order both to strengthen the warp threads and to make them smoother for weaving it is usual to apply some starchy or glutinous substance to them. This operation, which is performed in a machine called the Slasher, is termed yarn sizing, and consists of running the threads through a bath of preparation and then drying them quickly on a large steam-filled drum or can. One slasher will do enough work for 200 to 500 looms.



The Slasher

Healding

Since it is necessary that the warp threads may be lowered or raised in various combinations to allow the passage of the shuttle, each warp thread must be passed through an eye in the centre of a harness wire. Where, for instance, the warp is to be raised and depressed in three even sections there will be three harness frames, each fitted with enough heald-wires to accommodate one-third of the number of threads in the entire warp. In the Jacquard loom, used for intricate patterns, each warp-thread is separately controlled. The passing of the ends of the warp through their proper harness wires is a delicate and skilfull operation known as healding, or drawing-in. At the same time that this is done the threads are passed through individual stop-motion wires, relaxed tension on any one of which will bring the loom to a stop.



Drawing In

Reeding

Closely connected with drawing-in, is the final step in the preparation of the warp, and this is called reeding or sleying. In order to keep the warp threads in proper position during weaving they are passed through the wires of what looks like a comb with a strip across the open ends. This, the sley or reed, is attached to the batten on the loom and serves in addition to drive home each weft thread after the shuttle has passed.

Warp Tieing

When the loom has devoured all the warp threads contained on one beam, all that is necessary, if the pattern is to be continued, is to tie the ends of the old warp to the ends of the new, and this is accomplished with marvelous accuracy by a little machine built on the same principle as the Barber Knotter. This avoids drawing-in a second time.

Weaving Shed of Power Looms

When the preparatory processes have been completed the actual weaving is done, practically without human agency. The shuttle flies back and forth at the rate of from one to two hundred picks per minute, and when its thread is exhausted it drops out and, in the automatic loom, is immediately supplanted by a fresh one. The harness frames jerk up and down, forming and reforming the V shaped shed through which the shuttle passes; and after each pick the batten drives home the new thread into the ever-growing stretch of cloth. Like the film in a kodak, where a roller at one end gives out plain paper which is rolled up at the other end as a magic sheet of pictures, so in the loom the homely warp threads are rolled out at one end, while the roller at the other extreme winds up smooth gray cloth. *The Power Loom*

We have now made yarn out of cotton, and unbleached cotton cloth, or gray goods, out of our yarn. All that remains before the fabric goes to the finisher is an inspection for imperfections and their removal where possible, usually by hand.

4. Converting and Finishing

Cotton cloth as it comes from the loom has a gray or yellowish appearance due to the impurities it contains. The old-fashioned method of removing these consists in simply spreading the cloth in the sun for a few days until it is bleached white. Most cloth mills dispose of their goods in the gray and allow the finishing to be done by a separate establishment, although the large manufacturers of "fancies" sometimes do their own finishing. *Old-Fashioned Bleaching*

The first step in the finishing plant is to inspect the cloth and then to sew the ends of many pieces together into long strips. This greatly facilitates subsequent operations, because the cloth can now be run through various processes as a single unit. *Sewing Together*

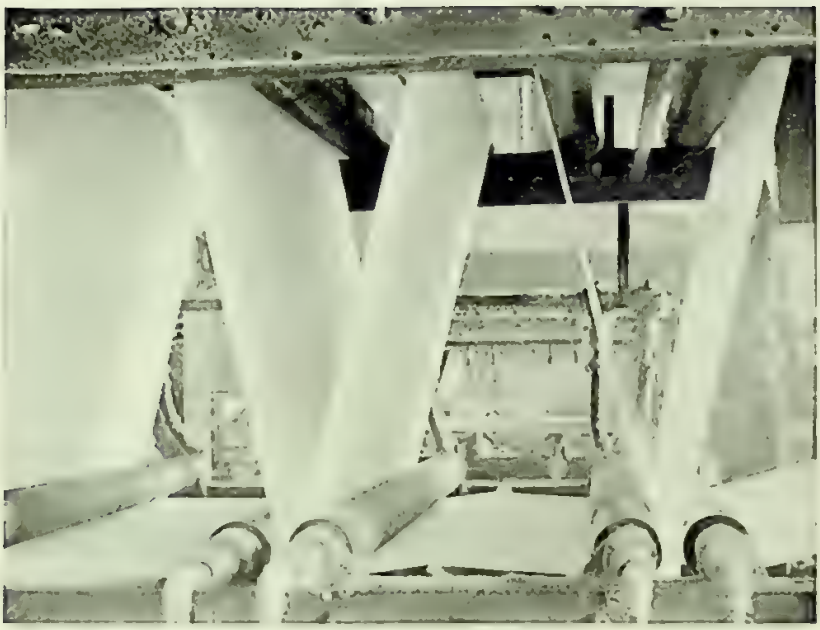
In order to obtain a smooth surface for later processes, the cloth is first run through a machine which brushes up the fibres and loose ends, much as a carpet-sweeper picks up the fibres of a carpet. Sometimes a bladed roller like a lawn-mower is used. *Brushing*

Removing the raised lint is a dangerous operation because it might easily damage the cloth, and this is usually done by the process of singeing. The cloth is run rapidly through gas flames or over hot plates and is quickly cooled. In this way the fuzz is burned off without injuring the cloth. *Singeing*

The next step is usually the bleaching process, except where the cloth is to be finished as a corduroy, velvet, or flannel. In the latter case it is

Inspecting

Sewing Ends Together



Singeing

first run through the napper, a machine which brushes up the fibre with wire teeth in such a way as to leave a raised face or nap. *Napping*

Bleaching is accomplished by boiling the cloth for several hours in large iron tanks known as kiers, which contain a solution of caustic soda. Next it is washed and scoured in dilute acid for several hours with the object of removing iron stains. Then it is again washed, boiled a second time, washed, run through a chemical solution of bleaching powder, and allowed to steep. After a last washing the cloth is dried by running over copper drums filled with steam, and is then rolled up in bundles about the size of a barrel. *Bleaching Process*

If the cloth is to be finished as plain white goods it is next starched and ironed (calendared), inspected, and put up in bolts for shipment. *White Goods*

If, however, it is desired either to dye or print the cloth with various colors and designs, it still has several treatments to pass through. White goods are sometimes mercerized, but more commonly this process is employed with cloth that is to be dyed. Mercerization is the treating of *Mercerization*

Napping

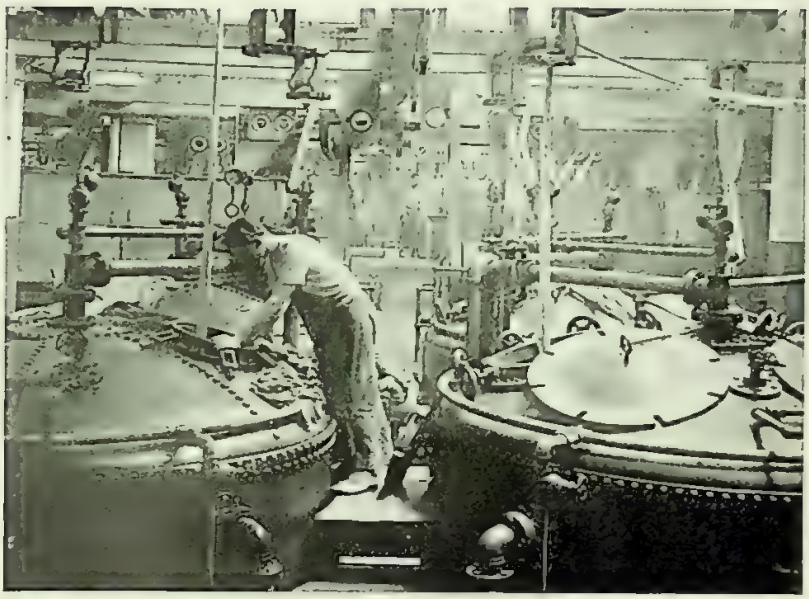
cotton yarn or cloth to the action of caustic soda dissolved in water, the remaining soda being removed by a wash of dilute sulphuric acid. The result is an increased strength of fibre, loss of elasticity, silky appearance, and an affinity for certain dyes and mordants.

Dyeing

The subject of dyeing is one of intense interest and wide scope, but it is unfortunately beyond the field of this brief survey. Suffice it to say that various chemical processes and mechanical devices are employed to give a permanent color to the cloth. (Yarn and raw stock dyeing are less commonly employed in the cotton than in the woolen and worsted industries.)

Resist and Discharge Printing

Some cotton cloth is simply dyed with a solid color and finished, but frequently it is first dyed with one color and then printed with others, or with a chemical which will discharge the dye and leave white figures wherever it touches the cloth. In contrast to this discharge method, where it is desired to obtain white figures on a colored back-ground, it is also possible first to print the figures with a chemical that will resist



Bleaching Kiers

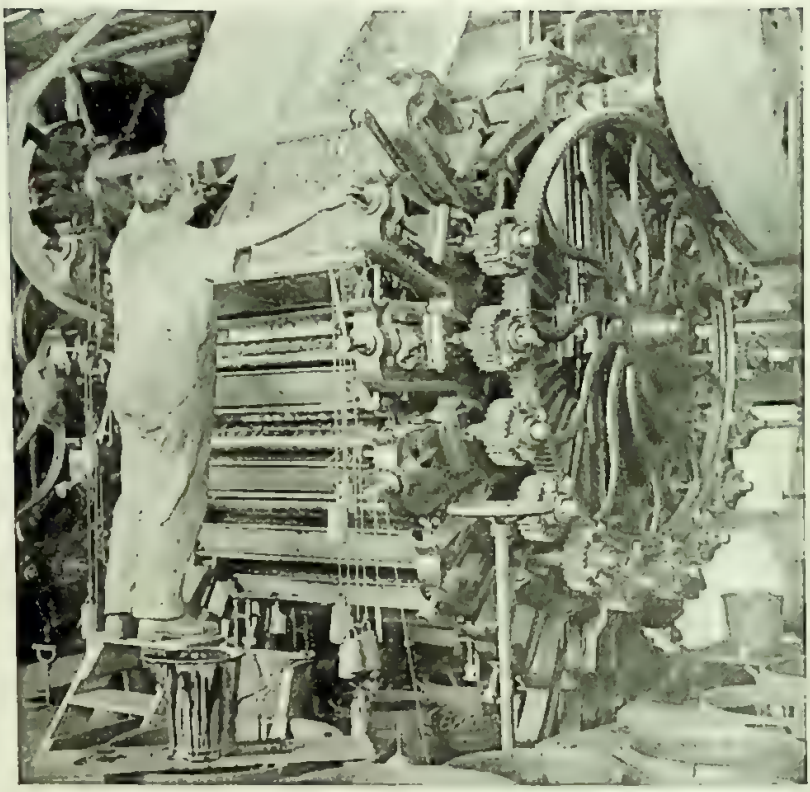
the subsequent action of the dye-stuff. Where a white ground is used and it is not essential that the colors and design appear on both sides of the cloth it is not necessary to dye at all.

Printing Process

The printing process is a very old one, and was employed centuries ago in China and India, where natives used to impregnate cloth with colored designs by pounding small wooden blocks carved and filled with color on its surface. The modern printing machine has a series of copper rollers in which the design to be printed is etched or sunk. Under each roller where it is fixed in the printing press is a trough filled with the particular coloring matter which that roller is to print on the cloth. As the mechanism revolves the roller is constantly supplied with new color, which is scraped off its surface except where the sunken design holds it, by a knife, called the doctor. If the design calls for six colors there will be six rollers at work, and so on up to fourteen colors at a single run through the press.

Engraving

An infinite number of designs are printed, and the method of getting them etched on the copper roller is a fascinating one. A zinc plate is



Printing Machine

carved by hand on a greatly enlarged scale from the original sketch, and from this plate the girls who operate the pantograph machines transfer the outlines of each color on to the copper rollers.

The Pantograph

When the roller is placed in the pantograph it is coated with varnish. As the girl traces the outlines of the design on her zinc plate with a little pointer, she presses a treddle which brings a number of little diamond points in contact with the roller. Each one of these points cuts through the varnish, reproducing the design in its original size. There will be as many points as the number of times the design is repeated across the roller. When the roller is finished it is given a bath in nitric acid which will eat into the copper where the varnish has been cut away, thus sinking the design so that it will hold color.

A Battery of Forty-eight

Aging and Washing

There remain now only the finishing operations before the cloth is ready to be packed for the market. Usually, after printing, the cloth is steamed, or aged, to make the colors fast. Then it is fixed and soaped thoroughly, after which it is run through the drier.

Starching

In order to give the cloth the proper "feel" an operation is next performed which closely resembles warp sizing. A certain amount of hot starch is pressed into the cloth, after which it is drawn through the tenter frames and not only dried but stretched back to its normal width. The tenter frame is about one hundred feet long and contains long lines of steam pipes. On each side an endless chain with clips grips the cloth and moving gradually further apart, these chains stretch the cloth, de-

The Tenter

Engraving Plate

livering it dry and of even width. (Some goods, notably those made for Asiatic consumption in England, are not only starched but filled with China clay, which adds over 100% to their weight.)

As it comes off the tenter the cloth goes through steel rollers and is pressed smooth, after which it is automatically folded and made ready for ticketing and packing.

5. The Knitting Industry

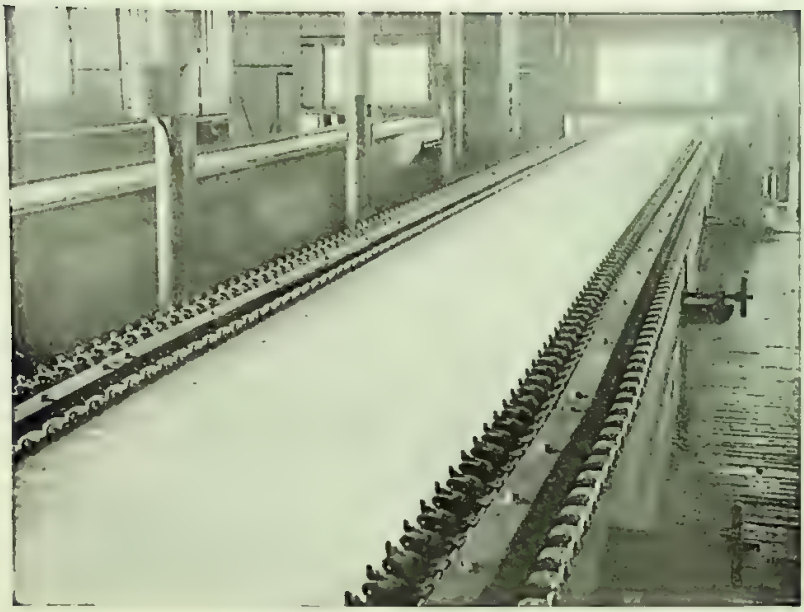
History

We have just seen by what processes cotton yarn becomes first gray cloth, and then finished goods. There is of course a tremendous variety

Transferring Design to Copper Roller

of woven fabric, ranging all the way from the coarsest sail cloth to the finest organdie. And there are certain finishes such as velveteen and corduroy which, for want of space, we have not even touched upon. There is, however, a whole class of cotton fabric which is not woven but knit; and since most of our hosiery and underwear are made in this way, it behooves us to take at least a brief glance at the knitting industry.

The principle of knitting is so familiar to every one who is or has a mother or wife that no description of it is necessary. Curiously enough, although the original stocking frame was invented as far back as 1589, power was applied to the industry for the first time at Cohoes, N. Y., in 1832. This city is still the centre of underwear manufacture in this country.



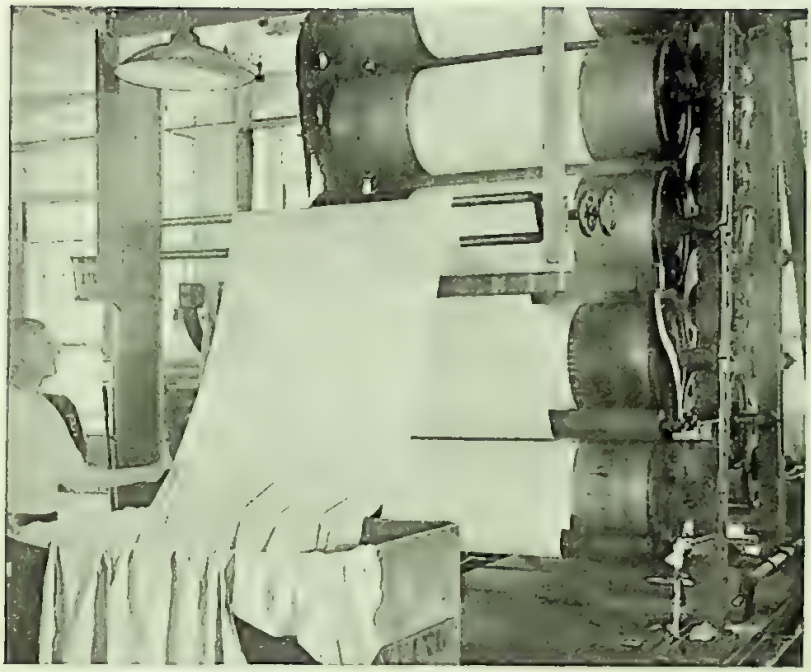
Cloth in Tenter-frame

Two Types of Machines

Knitting is now done on two general types of machines: the flat bed knitter, and the circular knitting machine. In the former the garment is knit in one flat piece and seamed afterwards. Underwear made in this way is described as full-fashioned. On the circular machine a seam is not necessary, for the complete cylinder of fabric is made at once. While it is possible to manufacture underwear on a circular frame, its use is far better adapted to the knitting of hosiery, and a very large industry for the manufacture of this product has grown up in and near Philadelphia.

The Flat Bed Knitter

The Cotton Knitting Frame, invented in 1864, is still the basis of the modern flat-bed knitter. The product is a flat web which can be widened or narrowed by transferring the loops from the edge needles to a separate instrument, and then replacing them. In knitting stockings, the shaped legs are made on one machine, then transferred to a heeler, and then to a third machine which knits the feet. The stockings then must be seamed up the back. The largest machines are capable of knitting twenty-four garments at one time. The advantage of this type is that it



Calendar

produces more elastic fabric, but it requires more operatives and more highly skilled labor than the circular machine.

The Circular Machine

A series of inventions made in Philadelphia from 1867 to 1889 perfected the completely automatic circular machine of which there are now more than seven times as many in use in this country than there are full-fashioned knitters. The seamless machine goes on continuously and manufactures the entire garment at once. Narrowing is done by shortening the loops, and this accounts for the loss of elasticity.

The finishing operations consist of seaming, where necessary, and removing imperfections.

Growth

The growth and importance of the industry is perhaps best realized from the fact that in 1870 there were 5,625 machines in the country, in 1905, 88,374, and now well over one hundred thousand. In 1850 men wore hand-knitted socks and flannel underwear. From 1860 to 1910 the product of the country's knitting machines rose from $7,300,000 to $200,100,000.

Folding

Cotton yarn is used more than woolen because it spins more cheaply and is less difficult to knit.

6. Other Cotton Products

Before concluding this part of our survey which deals with the manufacture of cotton into finished goods, we must at least enumerate some of the by-products and minor fruits of the industry.

Seed Oil

To begin with, at the time that the cotton is ginned the seeds are sold to the manufacturers of cotton oil. Without going into detail as to the process, we have here an annual product for this country worth $384,000,000. Seed mills regin the seed before they crush it and remove the short fibres which have hitherto adhered to the seed. This regained cotton is known as linters and amounts annually to about 800,000 bales.

Linters

Felt and Surgical Dressings

Being of very short staple this reginned cotton is adapted for the manufacture of felts and surgical dressings, both of which are important by-products.

The manufacture of small-wares and lace curtains is another minor branch of cotton manufacture. Here, however, domestic production is

comparatively small, and the bulk of the lace used is imported. Nevertheless probably over 75,000,000 yards* of the lace are made annually in this country. *Lace*

Gun-cotton, a highly explosive substance, is obtained by soaking cotton (usually linters) in nitric and sulphuric acids and then leaving it to dry. And again, gun-cotton dissolved in ether and alcohol yields the much used surgical adhesive known as collodion. *Gun Cotton* *Collodion*

The stems and leaves of the cotton plant are used for fodder, the seed hulls for fertilizer, and there is in fact no part of the plant from which man has not learned to derive some useful product.

*This figure is only roughly approximated.

CHAPTER III

FROM MILL TO CONSUMER

1. Industrial Organization

Before we proceed to discuss the various ways in which cotton goods are marketed we shall first take a cursory glance at the way in which the industry is subdivided.

The president of a cotton mill is usually not the active head of the business; his position corresponds to that of the chairman of the board of directors in the usual banking or mercantile corporation. The mill treasurer is, on the other hand, the chief directive force, and he performs the two all-important functions of buying the mill's raw cotton and selling its product, either direct or through other channels. In the mills of New Bedford and Fall River, which make chiefly gray goods, the treasurer usually has his office at the mill. In most other New England mills the treasurer is usually a member of a selling house and is frequently the treasurer for more than one mill. *The Mill Treasurer*

Where the treasurer has his office in the mill the man who has charge of the actual operation is known as the mill superintendent. His functions include the general management of the plant and the purchasing of supplies other than cotton. Where the treasurer maintains his office in a selling house, the operating head is known as an Agent and enjoys a greater degree of responsibility and independence. There are of course a varying number of minor operating chiefs in charge of sundry departments. *The Agent or Supt.*

The average New England cotton mill contains about fifty thousand spindles, while the Southern mill runs about twenty-five thousand. The vast majority of mills do both spinning and weaving, although some Southern mills sell yarn and some Pennsylvania establishments do *Spinning and Weaving in Same Plant*

nothing but weave. Of the entire number of spindles in the country, 83%, and of the looms 97%, are in mills which do both spinning and weaving.

Segregation of the Converter

In contrast to the tendency towards unification in spinning and weaving is the ever-increasing segregation of the converting plants. The rise of the merchant-converter, the growing demand for a great variety of finishes, and the fact that converting is very much cheaper on a large scale, have all brought about an increasing tendency on the part of the mill to sell its cloth in the gray, or to have it finished on commission.

Knitting

While a few large knitting mills spin their own yarn, this is the exception rather than the rule. On the other hand the knitting mills finish their product for the market themselves, and sell either direct or through a selling house.

2. The Distribution of Products

There are four general ways in which a cotton mill may dispose of its products: a. by selling direct, b. through a selling house, c. through a broker, d. through a converter.

a. Selling Direct

A few very large mills maintain selling offices of their own in the large centers of distribution through which they market their goods direct to the jobbers and retailers. In most cases where direct selling is done, however, the goods are sold in the gray by the mill treasurer at the mill. This practice is common with those mills which make staple gray goods and which, when not sold ahead, are able to manufacture for stock against spot sales. A few Southern yarn mills also sell direct.

b. Growth of the Selling House

The relation between the manufacturer and commercial banker or commission house is as old as the industry itself. Slater's first mill in 1790 was financed by Almy & Brown of Boston, who undertook to market his goods and also to furnish him the credit he needed to buy cotton and supplies. In the early days the cloth was sold at auction by the selling house and the proceeds less commission credited to the mill. Later on the factors developed extensive selling organizations throughout the country by means of which they were able to market the products of a good many mills.

"Fancies"

The distribution of fancy goods requires a great deal of skill. The Fall and Spring lines to be manufactured by the mills are sent out to the trade by the selling house about six months ahead, and orders are taken before manufacture begins so as to be sure that the line will "take". Of course there is always the danger of cancellations even then, for which the selling house must bear most of the responsibility.

In addition to distributing the goods and guaranteeing the accounts,

the commission house renders financial assistance either by advancing on the mill's product, or by indorsing its notes. In return it receives the sole agency for the mill's products, interest on the money advanced, and a commission. The latter varies with the amount of financial assistance required by the mill and the desirability of the risk. *Finances*

As a general rule the Southern mills, because of their distance from the chief markets in New York, Boston, and Philadelphia, are more dependent upon their selling agents than the New England manufacturers.

In New England a great number of manufacturers are amply able to finance themselves, and could if necessary sell their own products. Stock ownership, however, and old ties have frequently kept up the relationship with the selling houses after its usefulness was partly outworn. Nevertheless in the selling of fancy goods, even where the mill is supplied with plenty of capital, the commission house fulfills a very necessary function.

c. The Broker

Gray goods are very often sold either by a mill or a selling house through the medium of a cloth broker. The latter is strictly a middle man in that he does nothing but bring together prospective purchaser and seller. In the event of sale he gets a commission of ½%, which he often more than earns by his efforts. These brokers are in touch with all the mills, converters, and consumers.

d. Merchant Converters

While there are some independent finishing establishments, most of them operate on a commission basis for merchant converters. The latter are a class of merchants of comparatively recent origin, having appeared first about 1880, since which time they have practically taken control of the finishing industry. They buy gray goods either direct from the mill, or through a broker or selling house, and have them finished according to whatever they think the requirements of the market are. Inasmuch as they pay on short credit and carry the goods during conversion, frequently selling on several months' credit to jobbers and retailers, they perform an important part of the financing of the cloth. Their recent rapid rise has been due largely to the growing demand for a multiplicity of seasonal designs.

Some large cutters-up, and a few big mail-order houses do their own finishing or have it done. As a rule they buy from converters and sell to the jobber, retailer, or consumer.

We have now traced the cotton from the seed through the various processes of manufacture and finishing, and followed the finished goods through the channels of distribution to the consumer. It remains only for us to compare briefly the position of the United States with that of other countries, and the position of the various sections within the United States.

CHAPTER IV

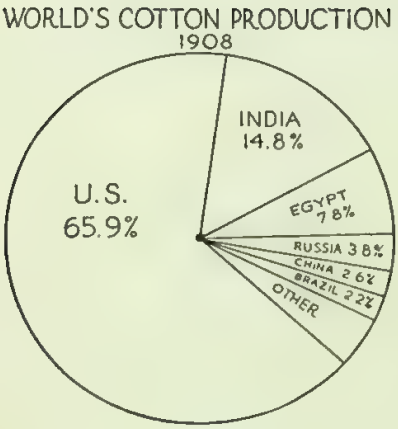
THE POSITION OF THE UNITED STATES

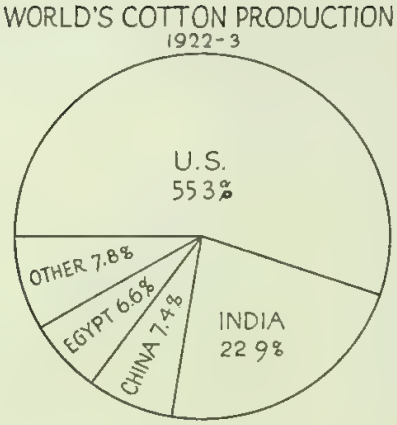
1. Cotton Production and Consumption

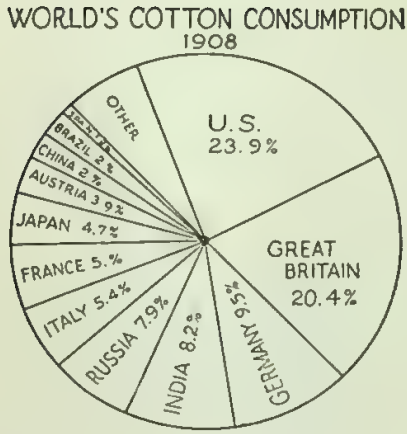
Ever since the Civil War the United States has produced more than half of the world's cotton crop. From 1860 to 1900 about one-third of the annual crop was consumed by the domestic industries, and from that time domestic takings have increased, except for 1921, to an average of about 50% in the last few years. During the same period the actual size of the annual crops increased enormously. If we take the figures from the present back to 1790 it will give a rough idea of the progress since that time.

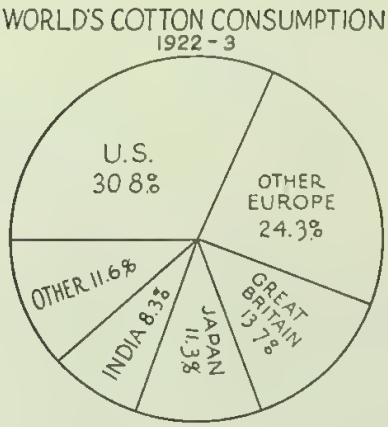
Year	Crop in bales (of 500 lbs.)	Exports	% of dom. takings
1790	3	1	66
1850	2,136	1,854	13
1860	3,841	615	84
1870	4,024	2,922	28
1880	6,356	4,453	30
1890	8,562	5,850	32
1900	10,266	6,806	33
1910	12,005	8,205	32
1915	12,122	6,405	47
1917	12,428	4,587	64
1919	12,028	6,760	44
1921	8,351	6,479	23
1922	10,369	5,049	52

(Expressed in thousands of bales)


WORLD'S COTTON PRODUCTION
1908
U.S.
65.9%
INDIA
14.8%
EGYPT
7.8%
RUSSIA 3.8%
CHINA 2.6%
BRAZIL 2.2%
OTHER


WORLD'S COTTON PRODUCTION
1922-3
U.S.
55.3%
OTHER 7.8%
EGYPT 6.6%
CHINA 7.4%
INDIA
22.9%


WORLD'S COTTON CONSUMPTION
1908
U.S.
23.9%
GREAT
BRITAIN
20.4%
GERMANY 9.5%
INDIA 8.2%
RUSSIA 7.9%
ITALY 5.4%
FRANCE 5.%
JAPAN 4.7%
AUSTRIA 3.9%
CHINA 2.%
BRAZIL 2.%
OTHER


WORLD'S COTTON CONSUMPTION
1922-3
U.S.
30.8%
OTHER
EUROPE
24.3%
GREAT
BRITAIN
13.7%
JAPAN
11.3%
INDIA 8.3%
OTHER 11.6%

THE INTERNATIONAL ACCEPTANCE BANK, INC. AND THE COTTON TRADE

The International Acceptance Bank, Inc., offers to Cotton Exporters a unique service. It is not only equipped to finance shipments to all parts of the world, but, because of the fact that it has as shareholders the leading banks and bankers of Europe, it is in a position to obtain unusual service, advice, and information for its clients.

The International Acceptance Bank, Inc., is constantly in touch with conditions abroad, and maintains extensive credit files on European cotton merchants and spinners. It not only finances millions of dollars of cotton exports every year for its domestic clients, but opens credits for an even larger amount in favor of American shippers by order of its clients abroad.

The International Acceptance Bank, Inc., deals actively in foreign exchange, and by reason of the large orders it receives from abroad, is often in a position to purchase foreign currency drafts of cotton shippers at exceptionally fine rates.

PART TWO

WOOL

By
James Paul Warburg
Vice-President
International Acceptance Bank, Inc.

Photographs by courtesy of
The American Woolen Co.

Grading fleeces

CHAPTER I

THE RAW MATERIAL

1. Sheep Raising

The raising of sheep goes so far back into primitive times that historians have been compelled to draw a veil over its origin. Whether sheep ante-date man, or man existed before sheep, is a question that has never been authoritatively answered. For our purposes very little history will suffice. We know that sheep were raised in Biblical times, but we do not know much about them. We do know, however, that the old Romans practised sheep-breeding with great care and even went so far as to cover their animals with cloth in order to preserve the clean quality of the fleece. During the reign of the Roman Emperor, Claudius (A. D., 50), an Italian named Columella, took several Italian sheep to Spain and crossed them with the native Spanish Merino breed. It is said that the resulting type is the progenitor of all the Merino breeds which now form the basis of sheep-breeding. Under the rule of the Saracens, Spain became not only a great sheep-raising country, but a woolen manufacturing country as well. In the thirteenth century there were no less than sixteen thousand looms in the town of Seville alone.

Early History

When the Saracens were driven out by Philip III. the textile industry disappeared from Spain, but sheep husbandry, which did not require skilled labor, remained, and Spanish wool continued to be the finest in the world.

Spain

During the eighteenth century various European countries began to import merinos and cross them with their native breeds. This, because of the sturdy quality of some of the native types, frequently produced excellent results. In France we thus have the origin of the Rambouillet merino, in Germany and Austria of the Saxony and Silesian breeds. In 1810 merinos were first introduced into Australia with astonishing results both as to grade of wool and increase of flocks. About the same time South America, South Africa, and the United States imported Spanish sheep. Of all the highly civilized countries, England is the only one where merino breeding was not successful. This was due in part to the climate, but the chief cause was the fact that British sheep-raising was primarily for mutton purposes, and only secondarily for wool. The merino types are smaller, and hence do not yield as good mutton carcasses as some of the native "Down" and "Mountain" breeds. In many cases, however, the native English breeds, notably the Lincolns, have been imported to other countries and there crossed with merinos with very good success.

Europe

Spread of Merino

It would not be possible to give in detail the various breeds of sheep existing in different countries. Merino sheep are now bred in many parts

Native Breeds

of the world, and, together with the high crossbreds, are the source of all the fine wools known as merino, half-blood, and three-eighths wools. Long wools are derived from various native breeds, chiefly English, and from the lower crossbreds of merinos, such as quarter and low quarter bloods. Chinese, Siberian, and Turkish wools, as well as many other uncivilized types, are usually very long and coarse, and are known as carpet and braid wools.

Sources

Most of the best merino wools come from Australia, the next best from South Africa, and from South America. The latter have one fault in that they contain many spiral burrs which are difficult to remove, and which frequently get through the machines and show up as imperfections in the cloth. Europe grows some very fine short wools, but these hardly ever leave the countries they are grown in.

U. S. Domestic

United States wools are known as "domestic" and "territory." Domestic wools are those grown in the eastern and middle western states, notably in the Ohio valley. These contain the highest grades of merino wools grown in this country. It must be remembered that sheep raising began in the East, and as civilization expanded, was gradually crowded further and further westward. The opening of the Erie Canal in 1825 made available the fertile pasture lands of the Ohio valley. The Ohio Canal eight years later opened up still more territory, and in 1849 during the famous gold rush, sheep were first taken to California.

Territory

The territory wools are those grown in the Rocky Mountain Plateau states. Recently, with improved methods and greater care in breeding, some very fine wools have been derived from Idaho, Wyoming, Nevada, and Montana, and from a few other states. The Texas and California wools are usually classed separately, because they are in most cases clipped twice a year. A little later we shall discuss the various grades and sorts of wool obtained from the different breeds, but as the wool is shorn or pulled before it is graded, we shall take up these processes first.

AVERAGE WEIGHTS OF DIFFERENT BREEDS OF SHEEP WITH WEIGHTS OF FLEECES

Breed	Ewes Pounds	Rams Pounds	Fleece Pounds	
Leicester	185	235	10	
Cotswold	200	285	12	
Lincoln	250	300	15	
Southdown	145	200	6	English Breeds (Mutton)
Shropshire	165	215	9	
Oxford	220	275	11	
Hampshire	200	275	8	
Rambouillet Mer.	155	235	18	
Amer. Merino A.	105	145	22	
" " B.	110	155	20	Merino Breeds
" " C. (delaine)	125	175	18	

2. Shearing and Marketing of Fleece Wool

Wool is obtained from the sheep in two ways; it is either shorn from the live animal, or pulled from the skin of the slaughtered carcass.

Shearing

Shearing was formerly done by hand. An expert was able to clip as many as one hundred head per day, but the average was less than half of that amount. The introduction of machine shearing has made it possible for one man to shear from 175 to 200 sheep in a day, and the fleece is very much more evenly clipped than formerly. Some merino breeds, known as type A, have so many folds of loose skin that machine shearing is not feasible, but except for these animals, and some of the type B or Rambouillet Merinos, almost all sheep are now shorn by machine, that is, where they are raised in numbers. Sheep raising in this country is not pursued with nearly so much care as, for instance, in Australia. There they have huge shearing sheds where the animals are first sweated and then carefully shorn. Whereas here the entire fleece is left in one piece, in Australia the belly is shorn separately and each fleece is carefully skirted, that is, the inferior parts such as the britch are torn off. Then each fleece is folded and tied up and the fleeces are put up in bales. Moreover, a bale usually contains fleeces of the same grade, so that practically nothing but sorting remains to be done by the purchaser. Here, on the other hand, fleeces are shorn in one piece and are folded up carelessly, without skirting. The tying up is frequently done in a slovenly manner, and a bag will very often contain all grades of wool from the finest to the coarsest. Of late years some attempt has been made to install the Australian system, but without much success.

Australian System

Seasons

The shearing season in the northern hemisphere is in the spring, in countries below the equator, except Australia, it is, of course, in our fall. In Texas and California, as well as in some other localities, shearing is frequently done twice a year.

Marketing

Roughly speaking, there are seven ways in which the wool grower may dispose of his fleece wool:

Merchant Buyers

1. He may sell it to buyers representing merchants. The merchant, while he is a middle man and therefore incurs the usual anathema, performs a variety of very essential services. At the time of the clip he sends his buyers to the wool producing centers and buys the clip for cash, then he ships it to his warehouse, grades it, and sells to the mills on credit. Obviously he finances a very important part of the production, and is furthermore essential, because he knows the demand, which the woolgrower does not, and the supply—of which the mill is usually ignorant.

Mill Buyers

2. The wool grower may also sell to buyers representing mills. He likes to do this because he eliminates the merchant's profit, but, as a matter of fact, there are only very few mills large enough to stand the

buying expense, and even fewer that can afford to buy their whole season's supply of raw material at one time and for cash. Also, mills can usually employ only certain grades of wool, and cannot therefore as a rule buy a whole clip.

Consignment

3. If the grower thinks that he is not receiving fair offers from the visiting buyers, he will frequently consign his wool to a merchant to be sold on commission for his account. In this case he may or may not get a better price, but it costs him his carrying charges plus commission. There are some wool houses that make it a specialty to execute commission sales of this nature.

Local Mills

4. Some wool is sold direct to nearby mills. This is done particularly in Ohio, where many of the smaller mills obtain their entire requirements in this manner.

Local Dealers

5. Wool growers sometimes sell to local dealers. This is particularly prevalent in regions where the individual grower's production is small. In most eastern states there are a great number of small farmers who grow a certain amount of wool. The local dealers are in many cases also the general store-keepers, and, since they are the farmer's creditor on other merchandise, and since the average farmer knows very little about the grades of wool, these individuals very frequently turn a handsome profit when they in turn sell to the visiting buyers.

Coop. Sales

6. Some wool is sold through farmers' co-operative sales agencies, but these organizations have in the past been so poorly administered, that, as a general rule they have not been successful. The movement is, however, gaining ground and has shown great progress during recent years.

Auctions

7. Finally, there remains the method whereby almost all the British and colonial wools are sold, namely, by auction. Auction sales have been established for almost a century in London, Liverpool, Antwerp, Bremen, Hamburg, Marseilles, and recently in Australia. This method of disposing of their raw product does not, however, appeal to the American growers, because of the inherent American trading instinct. It is also not very feasible in this country, because the wool is not graded in the shearing sheds and because sheep-raising in not standardized.

Markets

The chief markets for wool in this country are Boston, Philadelphia, Chicago, New York and St. Louis.

3. Pulled Wool

We have above discussed the shearing and marketing of wool obtained from the living animal. There remains a large quantity of wool which is taken from the pelts of slaughtered sheep. In 1919 there were

produced 48,300,000 pounds of pulled wool in the U. S. as against 265,939,000 pounds of sheared wool.

Skin wool, or tanner's wool, as it is sometimes known, is used extensively for soft twist yarns, bed blankets, flannels, felts, etc. It is also used as an admixture in blends for top-making, as we shall see later. *Use*

There are three methods whereby pulled wool is obtained.

The oldest and simplest process is known as sweating, and consists simply in sweating the hides until the wool is loosened and can easily be pulled out. The disadvantage of this method is that it injures the hides. *Sweating*

The lime process consists in loosening the wool by painting the flesh side of the hide with lime. This also injures the hides somewhat and has a bad effect on the dyeing qualities of the wool. *Lime*

The depilatory process is the best, and varies from the lime process only in that a solution is used instead of lime. This mixture consists of sodium sulphate, sulphuric acid, and oyster shells. *Depilatory*

By far the greatest pullery in the world is situated at Mazamet, France, where the industry has assumed gigantic proportions. The large packers in this country all operate their own pulleries, and the pulled wool is marketed largely by them. Most mills buy their pulled wool direct from the pulleries, but some is handled by merchants.

4. What is Wool

We have now traced the wool from the sheep's back as far as the bag, and may assume that the bag has travelled from the shearing shed to the merchant's or mill's warehouse. Some foreign wools, notably Australian and South American, are, as we have seen, skirted and roughly graded in the shearing shed, so that, when the bag is opened, there remains only the sorting to do. Grading is the separation of fleeces into classified groups. Skirting is the removal from each fleece of the worst parts, namely, the britch wool, manure locks (known as tags), and matted or kempy portions. Sorting is the dividing of the individual fleece into various classifications.

Before we take up the grades and sorts in detail, it will be well for us to inquire briefly into the nature of the wool fibre. In the first place, wool differs from hair in that its fibre consists of a core (medulla), a pulp (cortex), and an epidermis. A hair follicle consists of a medulla and an epidermis. Moreover, the epidermis of a hair is closely and evenly scaled, which makes it smooth and lustrous. The surface of a wool fibre is not evenly serrated, which accounts for the felting, or interlocking, quality. Wool in which there is insufficient moisture and natural grease (yolk) frequently becomes felted at the ends. Such wool is vari- *Wool as Against Hair*

ously referred to as cotted, cotty, or brashy. The tensile strength of a wool fibre is low, its elasticity high. The length of the fibre varies from one to over ten inches, and the diameter from .0018 to .004 inches. The better a wool the less like it is to a hair. Generally speaking, the finer the wool, the shorter the fibre, but length alone would not indicate the grade. Pure merino and high cross-bred wools have a close wave, known as crimp, which increases the elasticity and is therefore desirable from a spinning standpoint.

The chemical composition of wool is: carbon 50%, hydrogen 7%, nitrogen 18%, oxygen 22%, and sulphur 3%. It is soluble in alkalies, and at a temperature of 130° C. will reduce to powder.

Shrinkage

Wool before it is scoured contains a large quantity of yolk, or natural grease, and also, besides dust and vegetable matter, a considerable amount of dried perspiration, or suint. The amount of weight lost through the removal of these substances when the wool is scoured is termed shrinkage. It will be readily appreciated that this is a very important factor in connection with the purchase of grease wool. The percentage of shrinkage varies from 20% to 80%. Nevertheless a good buyer will often be able to estimate within one or two per cent. The factors to be considered in this connection are the breed, the soil, the climate, and the care with which the sheep are raised, as well as the diligence with which the fleeces are put up. Fine wools always shrink more heavily than coarse; and pulled wools, since they are washed and brushed during the process, show a very much lower shrinkage than fleece wools. The average shrinkage of United States wools is about 55%. Fine domestics shrink about 60%. Lower grades about 45%. Fine territory wools about 65%; lower grades about 55%. Pulled wool averages about 27%. Fine Australian wools average 49%, for, although they are the finest, the fleeces contain less dirt. Cape wools about 62%, and South American about 51%.

Qualities Desired

The qualities looked for in wool are roughly six, and they vary according to the purpose for which the wool is to be used.

1. It must be fine enough to spin the required number of counts.
2. It must be strong enough to withstand strain of manufacture.
3. It must have the proper staple (length).
4. It must be of a certain softness or hardness.
5. It must have the proper felting qualities if the material is to be fulled.
6. It must either scour white, or else have sufficient lustre to take dyes.

As we take up the manufacture of worsted and woolen yarns we shall see how these qualifications play a different part in the two processes.

Sorting Wool

Clothing and Combing

At the outset the only important difference we are concerned with is staple length. Generally speaking, wools under two inches are too short to be combed and are classed as clothing wools. *Clothing wools are used for woolens, combing wools for worsteds.* This applies only to wools of fine fibre. The mere fact that a wool has long staple length does not make it a combing wool. As a rule, the coarser the wool the longer its staple, and the longest wools are the exceedingly coarse "common" or "braid" wools, which can only be used for carpet manufacture.

In grading and sorting, practically the only guide is the fineness of the individual fibre. The other qualifications just enumerated have a very important bearing on what the wool can be used for, but they have very little to do with its classification by grades.

Classifications

Fleece wools are graded by two systems, one by bloods, the other by counts spun. (This means the number of hanks of 560 yards each to a pound of yarn.) Domestic and foreign wools are usually graded by bloods. U. S. Territory wools are graded a little differently, as per second column below, and pulled wool is only roughly graded into four

classes (third column). The blood classifications originated from the breeding of the sheep, but, as a matter of fact they have become arbitrary terms denoting a certain degree of fineness. The same fleece may, and frequently does, contain ½, ⅜, and ¼ blood wool.

COMPARATIVE GRADES

U. S. Domestic	U. S. Territory	Pulled	U. S. Counts Spun	Foreign Counts.
Full blood (XX)	Fine	AA	60s	66-74s
¾ " (X)	¾		50s	60-66s
½ "	½	A	40s	54-60s
⅜ "	⅜	B	36s	48-54s
¼ "	¼	B	32s	44-48s
Low ¼	Low ¼	C	20s	40-44s
Common	Common	C	16s	36-40s
Braid	Braid	C	12s	32-36s

Grading

Skirting

Sorting

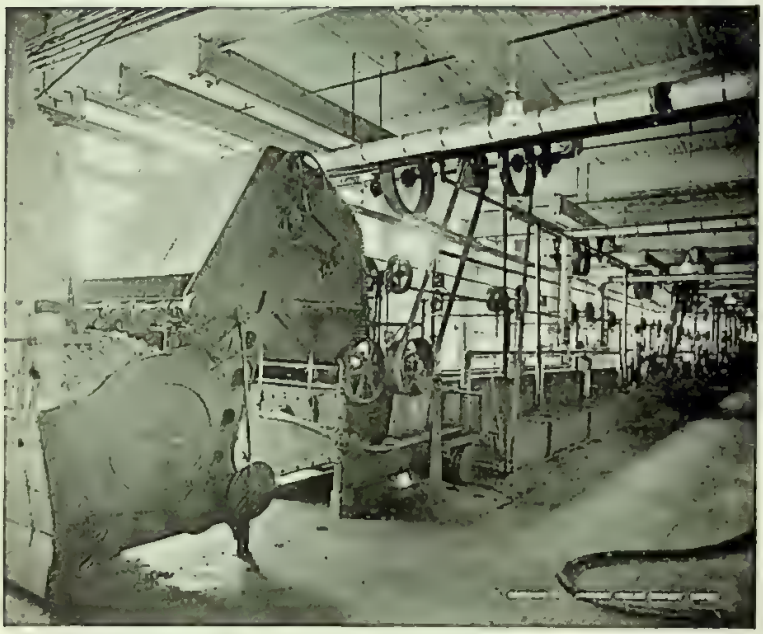
When a bag of domestic wool is opened the fleeces are taken out one by one and put into baskets according to the grades in the first column. The grader simply decides what the majority of the fleece is and puts it into that class. When he has filled a basket with, let us say, half-blood fleeces, this basket is given to a sorter. He takes each fleece, shakes it out, and, first of all, skirts it. Then he separates it into the various sorts it contains. Fleeces graded as half-blood will probably sort into mostly half, some fine (full-blood), and a considerable quantity of three-eighths blood. The best wool comes off the shoulders, then the sides, then the back, then the thighs, and finally the britch and belly. Usually a fleece will not contain more than three sorts.

If this were a bag of Australian, South American, or Cape wool, the fleeces would in all probability have been bagged according to grades, so that only the sorting operation would have to be performed by the merchant or the mill.

When the wool has been sorted it is put into bins, and may now be said to be ready for the first of the manufacturing processes for which it is destined. Sorting is sometimes done by the merchants, but more frequently by the manufacturers.

Off-sorts

Kempy or cotted pieces, tags, stained or painty wool, etc., are called off-sorts, and these are put through a number of processes for the purpose of reclaiming as much of the wool as possible.



Scouring Machine

CHAPTER II

WORSTED MANUFACTURE

1. Scouring

When the wool has been graded it is sold either to worsted manufacturers or to makers of woolen goods. The two industries are entirely distinct and separate.

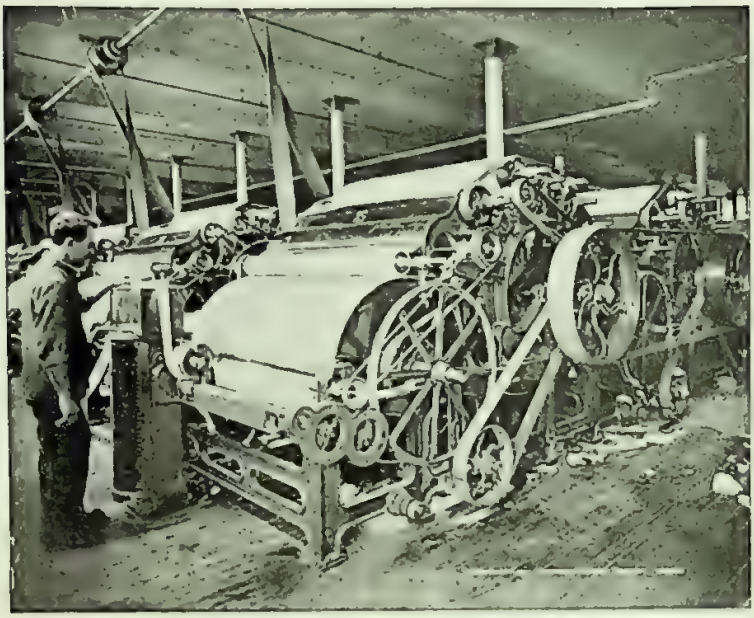
The first cog in the worsted machine is the wool comber, or top-maker. Sometimes he buys assorted grades, known as matchings, from a wool merchant; sometimes he buys and sorts his own wool; but most frequently he sorts and combs the wool on a commission basis. Many of the big worsted mills do their own sorting and combing.

Blending

Tops are usually made from blends of various kinds of wool, and this blending is done after sorting, before the wool is scoured.

Scouring

Scouring is nothing more or less than a glorified washing. A machine closely akin to a gigantic laundry machine removes first the yolk or



Worsted carding Machine

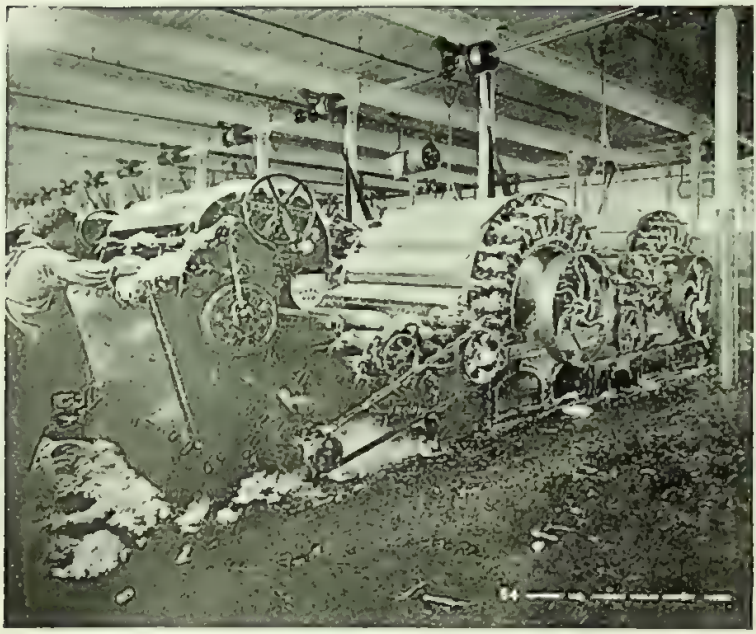
grease in an alkaline solution, and then rinses out the dirt and suint in a series of soap and water baths. The last bath is pure water, and from this the wool is taken on a belt through the drier. From the drier it is usually blown through tubes to the carding room.

Approximately 20% of the moisture is allowed to remain in the wool in order to facilitate subsequent processes. If the wool is still warm it is easier to card.

2. Carding

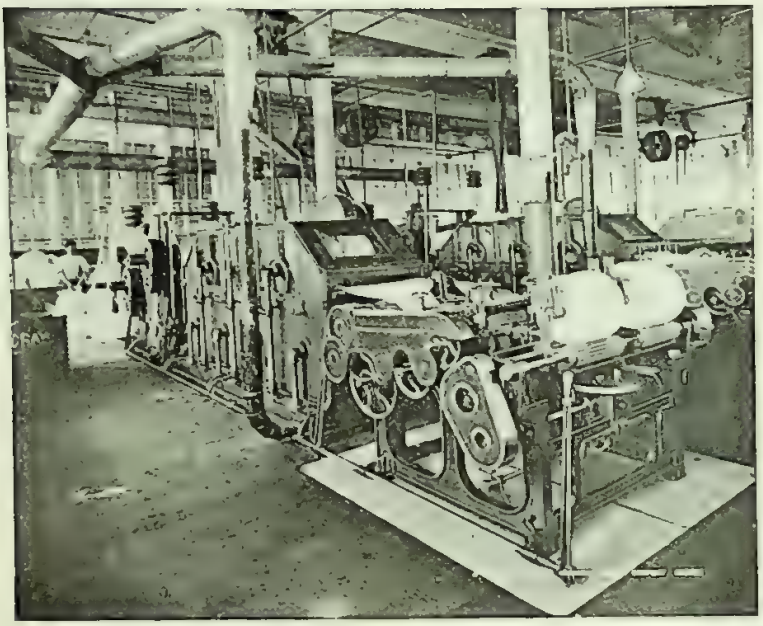
Opens Fibres

The purpose of the carding operation is to open out the fibres in the wool. Originally, carding was done by hand with two leather surfaces, much like butter pats, the inner faces of which were studded with wire nails. Between these two surfaces the wool was rubbed until all the fibres were opened out. In woolen manufacture carding is more violent and seeks to lay the fibres in all directions. Worsted carding aims to separate the fibres, but also to keep them as closely parallel as possible.



Woolen card. Feed end

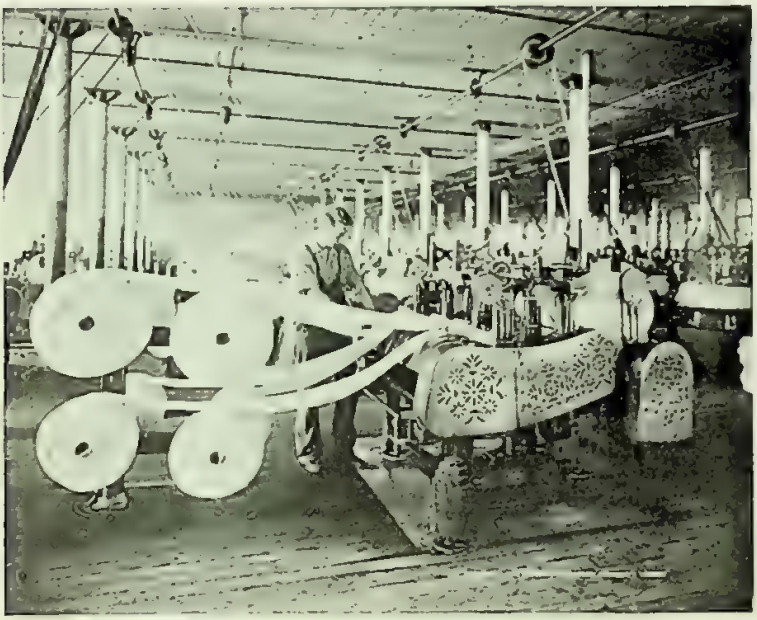
Woolen card. Condenser end



Back Washing

The Card

The carding machine is somewhat similar to that used for cotton (see page 22). The wool is automatically fed between the feed rollers, which revolve in opposite directions and are armed with heavy teeth. From the feed a roller known as the licker-in starts the wool on its course over a number of cylinders, each of which is surrounded by several toothed rollers known as workers. Each worker has a smaller companion roller, revolving at a higher speed, which derives its name of stripper from the fact that its function is to take the wool off the worker and deliver it to the next worker. The last roller, known as the fancy, raises the wool off the cylinder to be caught by the doffer. The doffing-comb lifts the wool in a filmy sheet of fibres, which is condensed into a thick untwisted rope by passing through a funnel on to the balling-head. This rope, which is about an inch and a half in diameter, is known as a sliver. A certain length of it is automatically rolled into balls and these are taken into the back-wash room. From a loose unrelated mass the wool has now been transformed into a continuous strand of more or less uniform diameter.



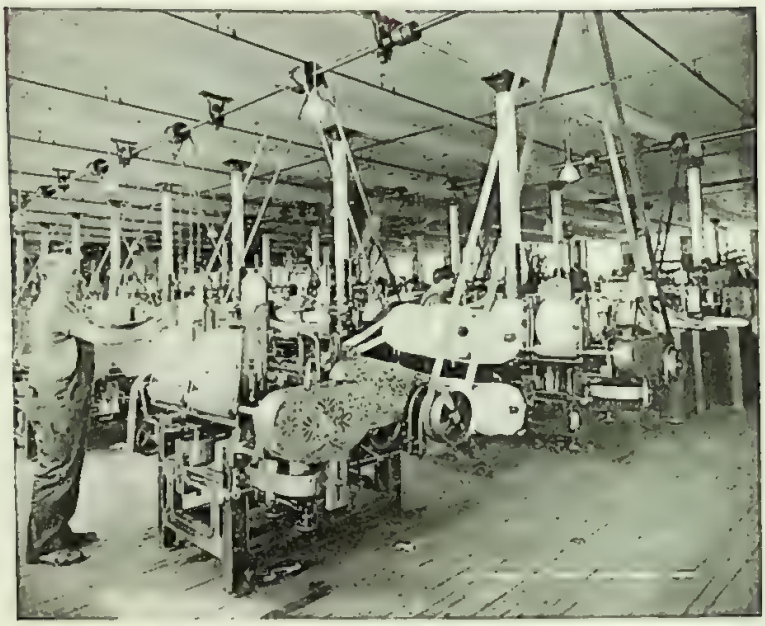
Gilling before combing

3. Backwashing and Gilling

A back-wash machine takes several of the carded slivers and combines them into one. The slivers pass through several baths which rinse them thoroughly and are then slowly drawn through a drier. The process is quite similar to scouring, except that it is very much less violent.

As the slivers come out of the drier they are fed through a number of gill boxes. The gill box is the first of a long series of drawing operations. In this, and all the following stages of open drawing, there are always several slivers being combined into one and drawn out until the resulting sliver has about the same or a smaller diameter than the ones fed into the machine. The principle of the gill box is quite simple. Several slivers are fed in between rollers revolving at a comparatively low rate of speed. As they pass through they are flattened out over what is known as a faller. This is armed with very fine close wire teeth which come up through the fibres and the draft is imparted when the wool is taken off the faller by a final pair of rollers which are revolving considerably faster. The sheet of wool which emerges from these rollers is

Combining and Drawing Slivers



Gilling the top

again passed through a funnel and thereby condensed once more into a sliver. This operation is repeated from two to four times, according to the quality of the top desired, and the methods employed by the particular mill.

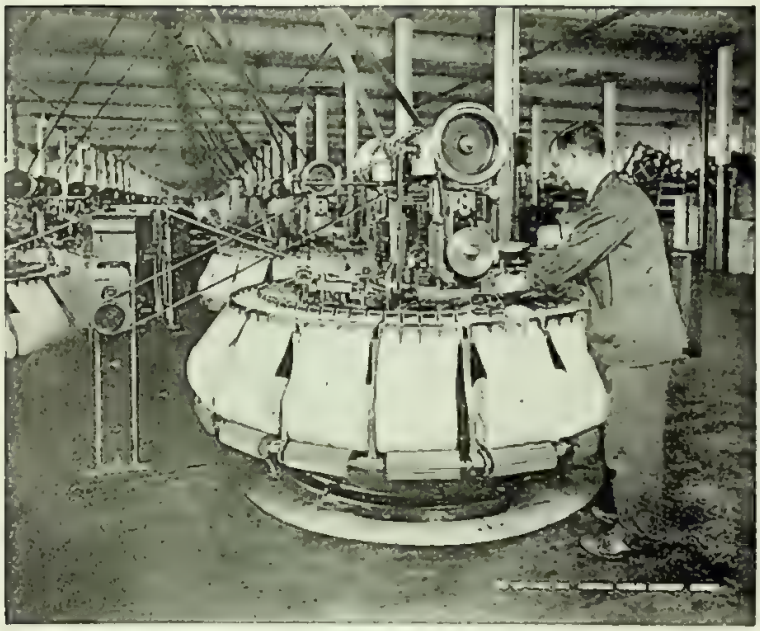
Where very coarse long fibred wool is to be worked there is no carding, and the wool is prepared by straightening the fibres into a sliver through a series of gill-boxes.

At some point during the gilling process a slight amount of oil is usually dropped onto the sliver, as this facilitates combing.

4. Combing

Removes Short Fibres

The next operation, namely that of combing, is again simple when viewed as the primitive manufacturing process. The old comber would take a short length of sliver, hang it on a nail by tying one end together and then proceed to comb out the short fibres much as one may comb out the dead short hairs from a dog's coat. Combing is simply the removal from the sliver of the short fibres which would not spin properly.



The Noble Comb

These short fibres are known as noils and are the waste product of top-making. The top is a continuous untwisted strand of long wool fibres made parallel by the comb. (By long fibres we mean fibres which are relatively long. Some tops consist of fibres less than an inch and a half in length. In this case, which is very infrequent, the noil would be even shorter.)

Noils

Noils are sold either to woolen or knitting mills direct by the top-maker, or else to a merchant who disposes of them.

The Noble Comb

The Noble circular comb is the most generally used combing machine. Other types are the Lister, the Holden, and the Heilmann. The Noble comb is a compact circular structure standing at a height of about three feet from the floor, with a steam box underneath it. (Heat greatly facilitates the process.) There are two smaller circles inside the main circumference which are tangent to the outer circle at opposite points of its diameter. All rotate in the same direction. Seventy-two slivers are rolled up in creels on the outside of the main circle and are automatically fed on to the tangental points. A dabbing brush pushes the slivers

down between the points of the two circles. As the circles draw apart the long fibres are left protruding from the inner edge of the outer circle and the outer edge of the inner circles. They travel thus until they are gripped by vertical rollers set to catch them. After passing the rollers the wool is lifted off the pins of the circles by knives. The four ribbons of combed fibres (two from the outer and one from each of the inner circles) are condensed into a single beautiful even band which coils itself softly into a revolving can. What remains is the waste or noil.

Gilling the Top

The top, as it comes from the comb, is again put through a series of several gill boxes with the object of further drawing it out. Once again several slivers are combined into one in each process. At the end of this gilling the top is coiled in balls and allowed to rest.

We have now reduced the wool to its real worsted basis. The noils have been taken out, and the balls of top are ready to be sent to the spinner to be spun into worsted yarn.

5. Spinning

The first processes in a spinning mill very closely approximate the last operations in the combing plant. The tops are usually gilled several times before weighing, and then are put through several drawing machines in which, as heretofore, several slivers are condensed into one. In the last of these machines there are no fallers, the entire process consisting of two sets of rollers revolving at different speed. Each operation results in a slightly finer sliver, and the number of machines through which the material is drawn is determined by the fineness of the yarn desired.

Drawing

The last of the drawing processes is the so-called roving box, which, in most cases is a cone-drawing process. There is a difference here between French spinning and English spinning. According to the French system, which is employed in this country only for very soft fine yarns, no twist is given to the sliver until the actual spinning begins; and the spinning is then usually done on mules, which in this country are rarely used in the manufacture of worsted yarn. We shall discuss these machines when we come to woolens. According to the most common procedure in this country, the roving box not only draws, but imparts a certain amount of twist to the yarn. This is done by winding the yarn from horizonal spools on to vertical spindles. These spindles are set on long frames, similar to spinning frames, one frame containing about 200 spindles. The yarn is guided on the bobbin by an arm, known as the flyer, which draws the bobbin around after it.

French

English

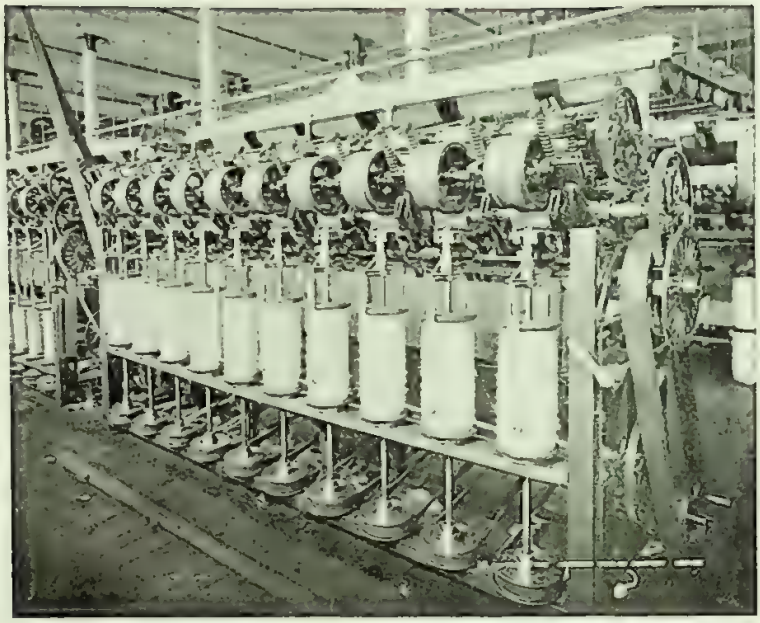
There is very little difference between this last drawing operation and the actual spinning which immediately succeeds it. In both cases the

Spinning

Drawing

yarn is unwound from horizontal spools placed at the top of the frame through the inevitable two rollers going at different speeds, and guided on to the revolving spindle. Since the spindle revolves vertically the yarn is twisted. The amount of twist is regulated, as is also the amount of tension, and these two factors, together with the quality of the material, determine the quality of the yarn. Worsted yarn is graded according to the number of counts, which, as we have seen, is the number of hanks of 560 yards that make a pound avoirdupois.

Roughly speaking, there are three modern methods of spinning, namely, the flyer, cap. and ring frames. All of them are derived from Arkwright's original water throstle. and, if we want to go further back. from the old-fashioned spinning wheel. The chief difference between the



Reducing

Flyer

three types lies in the method of driving the spindle and guiding the yarn on to the bobbin. The flyer arm we have described briefly above.

Cap

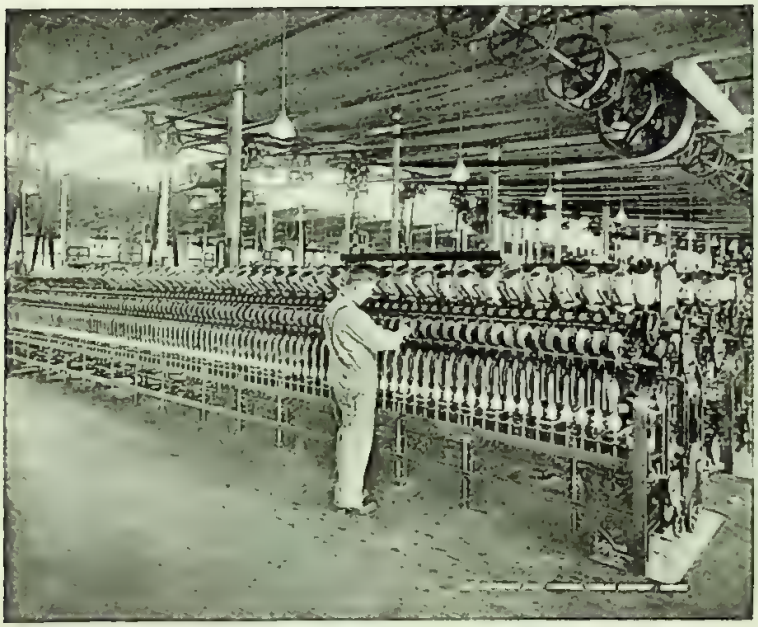
In the cap system, the bobbin is moved up and down in a fixed metal cap, something like the front end of a two-inch shell-casing, and this method of guiding the yarn has the advantage that, because of its lower vibration, the spindles may be driven faster. It also causes considerably more friction on the yarn. For worsted spinning it is probably the most commonly employed. Ring spinning, the most frequently used for cotton, and described briefly on page 28, is very similar (to the layman)

Ring

except that the spindle revolves in a metal sleeve. and that the yarn is guided by a metal ring with a traveller, instead of by the end of the cap.

Twisting

What follows now is merely an auxiliary process of spinning. The yarn has been completed, but it is rarely used for weaving. as it comes off the spindle. Several strands are usually twisted together, both to make it stronger and to give various effects of body and color. The number of strands in a yarn are designated as plys. Yarn consisting of two strands is called two-ply, three strands are three-ply, and so on. Yarns



Cap spinning

of two or more colors, or yarns of varying counts, are frequently twisted together. It is possible also to twist worsted and cotton yarns.

Twisting is done in a manner similar to spinning. A worsted spinning mill usually has about a third as many twisting spindles as spinning spindles, but it is important to remember that when speaking of a mill's capacity in terms of spindles, it is only the spinning spindles that are counted. *Spindlage*

After the twisting is completed the finished yarn is wound on small spools, known as cheesers, to be weighed. Next it is wound on large spools in such a way that the large spool holds the contents of from ten to twenty cheesers, each wound in an adjacent space at the same time. Some of the yarn is shipped to weaving mills on these large spools; and some of it is taken off them and skeined. *Winding or Skeining*

We are now ready to weave the cloth, but there are a considerable number of very interesting details which we have been forced to omit. All the processes we have discussed produce a certain amount of waste material. The combing waste, known as noils, is the largest by-product *Waste*

of the worsted industry, but there is also a considerable amount of yarn waste produced in the various drawing and spinning operations. Practically all of this material finds its way back, in one form or another, into the woolen industry. The subject of reclaiming waste is in itself so comprehensive that we can do no more than touch upon it here.

6. Dyeing

Some yarns are dyed after they have been spun. In most cases, however, woolen yarns receive their color after the wool is scoured and before it goes into the carding machine. In worsted manufacture the common procedure is to dye the top after it has been combed. In this way a uniform color is obtained, whereas it is exceedingly difficult to obtain the same color from two vats in piece-dyeing. Some materials are both wool and piece-dyed, the second dye being given to the cloth. This is done in cases where a peculiarly fast color is desired, or where the cloth contains separate materials such as wool and cotton.

Wool and Piece and Double Dyeing

The operation of the loom has already been described in connection with the manufacture of cotton, but the preparatory processes, although somewhat similar, vary considerably because of the difference in the nature of the materials. In worsted manufacture the work which has to be done before the loom can begin to operate is usually referred to as loom-mounting, and consists of five stages.

1. Warping is the arranging of the warp threads in the order necessary to produce the desired cloth. This was formerly, and still is to a great extent, done entirely by hand on a sort of rack known as the woof. In the larger mills, however, warping is now done either on a sectional warping machine or on the warping mill. Both these devices are only partly automatic, and require highly-skilled labor.

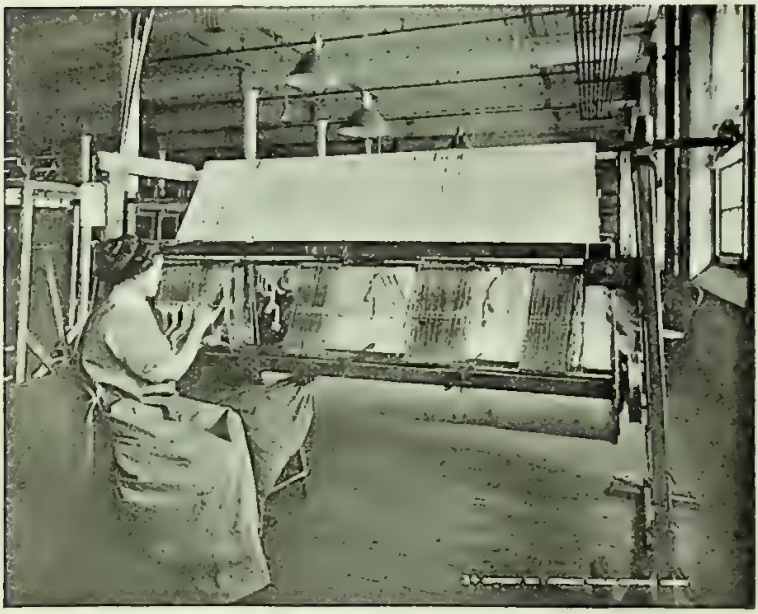
Warping

2. The mechanical structure of woolen or worsted yarns necessitates the application of some glutinous substance to their surfaces before subjecting them to the weaving process. No matter how even the worsted yarn, a microscopic examination would show certain fibres protruding from the surface. Sizing has the effect of smoothing the surface of the yarn, and at the same time distributing more evenly the strain of weaving. The sizing machine is rather like the back-washer used in the manufacturing of worsted yarn. The warp is run through the sizing bath and then compressed betweeen rollers, after which it is dried by steam or fan.

Sizing

3. Beaming is the term applied to winding the warp upon the beam of the loom. (The beam is the roller from which the warp threads are unwound as the weaving progresses.) In order to keep the threads in their proper position an instrument known as a raddle is employed, and the raddling process is one which requires considerable care.

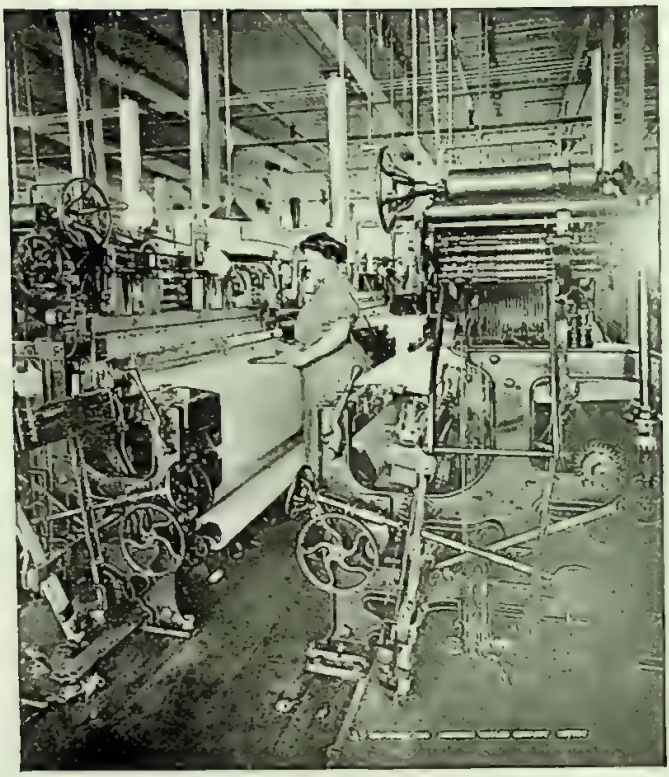
Beaming



Drawing in the warp threads

4. The next step, healding, is the same as that described on page 34 and enables the warp threads to be lifted in sections in order that the shuttle may pass under some and over others. From the original weave of lifting alternate threads, a great many complicated designs have been evolved, which necessitate the lifting of the warp threads in many small series. In the elementary weave where there are only two groups, this work is done by heald-wires which raise the odd and depress the even threads, thus forming a V, known as the shed, through which the shuttle may pass. As the design becomes more intricate the healding process becomes more complicated, and the number of heald shafts increases. *Healding*

5. Sleying, or reeding, is the final preparatory process, and has the object of keeping the warp threads the proper distance apart during weaving. The sley is really nothing more than a fine comb with a strip across the ends of the teeth. The warp threads are passed between the wires (reeds) of the sley and are so compelled to keep their proper position. *Sleying*



Weaving

The sley is attached to the batten, or fly, and as in the cotton loom performs the additional function of driving home each weft thread after the shuttle has passed.

The Power Loom

Once these processes have been completed the remainder is almost entirely automatic. The shuttle flies back and forth without aid. The proper warp threads are raised and lowered to let it pass, and after each traverse, or pick, the batten automatically drives home the weft thread, into the growing stretch of cloth that is winding itself up on to the beam at one end, while the beam at the other end delivers the parallel warp threads. The average worsted loom makes about 100 picks per minute. which is only about half as fast as the calico loom, the reason being the lower tensile strength of the yarn.

8. Worsted Finishing

While, as we shall see, finishing in the woolen industry is a very important stage of manufacture, worsted materials are practically unchanged after they come out of the loom. There is sometimes a certain amount of fulling and raising and cropping, but the net result does not in any way alter the cloth, except perhaps to impart a little smoother finish. We shall discuss finishing in a little more detail when we come to the last stage of woolen manufacture.

Our worsted cloth is now finished, and we have traced its origin, somewhat sketchily, from the back of the sheep up to the point where it takes only a tailor to put it on the back of a man.

CHAPTER III

WOOLEN MANUFACTURE

1. The Manufacture of Woolen Yarn

We have taken the worsted industry first, not because it is necessarily any more important than woolen manufacture, but because its processes are more complicated, and therefor, if we have gained a certain amount of familiarity with them, we are able to take up the sister industry in a more abbreviated manner. Although, at the present time, the demand for worsted materials is a great deal heavier than the demand for woolens, the woolen industry is by far the older of the two, and may rightfully claim that the worsted branch is really an off-shoot of its tree. Moreover, while broadcloth and similar material no longer enjoy their erstwhile popularity, there is still a tremendous demand for other products of the woolen industry such as blankets, flannels, overcoatings, etc. And we must bear in mind that most of the cheaper clothing materials are woolens.

Raw Material

In the sorting of wool we saw that the shorter staples were classed as clothing wools. To these must be added the noils from worsted combing, yarn waste, and wool reclaimed from off-sorts, as well as wool extract made from rags, before we have the raw material for the woolen industry.

Scouring

Whereas we found that combing wool had to be left in the grease until it could be carded immediately after scouring, the maker of woolen yarn will buy wool that has been scoured months before. Most of the wool that is scoured by or near the growers finds its way into the woolen industry for this reason. The scouring given to clothing wool varies only in that it is more violent than that given to combing wool, and in that it is frequently augmented by carbonization to remove vegetable matter.

Mule Spinning

Blending

The first process after scouring is blending. When the desired mixture of various grades, kinds, and colors of wool, wool extract, or cotton has been effected, the resulting heterogeneous mass is put through the first of several carding processes.

Fibres not parallel as in Worsted

From now on the desire of the woolen yarn manufacturer is diametrically opposed to that of the worsted comber. He wants to open out the fibres, but he wants them to lie in all directions. He does not want uniformity. He wants just the opposite. His yarn must have a certain amount of strength, but it must have, first of all, felting properties, so that when the cloth is finished the various threads will merge and interlock. As might be expected, therefore, the carding process is very much more violent.

Carding

The blend is first put through a fearnought which might be described briefly as the most pitiless member of the card family. It is also known as a tenter-hook-willy, from the reversed position of its teeth. From this machine the wool goes through the card proper, which is similar to the worsted card except that the rollers go in opposite directions, instead of in the same directions. Here, again, the doffer lifts the wool off in a

Burling and mending

continuous filmy sheet and delivers it to the condenser. The sheet is not simply drawn through a funnel into a single thick sliver, but is forced between rollers into two leather rubbing aprons which by pressure and friction reduce it to a series of small soft flabby slivers, having just enough adhesiveness to permit of mule spinning. *Condenser*

The fibres in these slivers may be of all lengths and degrees of fineness, and they lie in all directions.

There are now no elaborate drawing or combing processes. All that remains to be done before we have a weavable woolen yarn is a certain amount of twisting and attenuation. Both these results are obtained at once in the mule.

In a woolen mule the spools of sliver are placed in a fixed frame, and the sliver passes between a pair of rollers to the spindles. These stand, slightly inclined backwards, in a long row upon the movable carriage. At first the spindle tips are close to the rollers. The sliver is paid out, and at the same time the carriage bearing the revolving spindles retreats. *Mule Spinning*

During this time no yarn is wound on the bobbins, but the slivers are being twisted. Then the rollers cease to pay out sliver, the carriage moves out a little further, and the spindles rotate faster, so that the yarn is being twisted and stretched. When sufficient twist has been imparted the carriage moves back again and the spindles wind up the twisted yarn on to the bobbins. This, briefly, is the operation of the mule. There are a great many intricate devices in this machine which deserve attention, but which hardly fall within our scope. All that remains now is to wind the yarn on spools, or skein it, before it is ready for the weaver.

2. The Manufacture of Woolen Cloth

Weaving

There are many differences between weaving worsteds and woolens, but for our purposes we may consider the process the same, as in a general way it is. Some cloths are woven with a cotton warp and a woolen yarn filling, the warp being carefully concealed. Woolen cloths are more frequently woven with a backing than worsteds. This means that either there is a double warp, a double weft, or both. The object of backing is usually to add strength and warmth to the material, and the lower side is therefore often woven of coarser yarn. In some cases, however, notably in travelling rugs, the backing may be just as elaborate as the face, and this necessitates a rather intricate mounting process.

Carpets

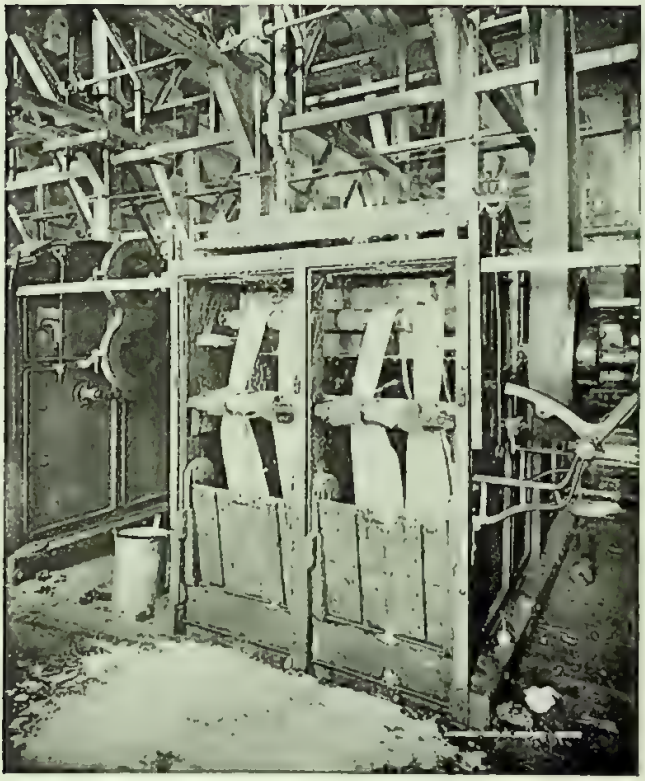
Carpet weaving is one of the large branches of the woolen industry, and for this purpose the coarsest and longest fibred wools (common, braid, and carpet wools) are usually employed. These wools readily lend themselves to the manufacture of a coarse thick yarn, which in turn produces a thick, durable material. The thickness of a carpet is known as the pile.

Finishing Important in Woolens

Whereas we saw that the worsted cloth was practically finished when it left the loom, this is not the case with woolens. Oftentimes it would tax an expert to identify the finished goods with the loose and altogether different material produced by the weaver. Some fine woolens, it is true, are scarcely altered more than worsteds, but in most cases the finishing operations are in this industry a major rather than a subsidiary stage of manufacture. The reader may have been puzzled at the divergent lines along which woolen and worsted yarns are manufactured, and at a loss to account for the reasons. The cause is precisely this, that the worsted manufacturer aims to produce a cloth that is completed when woven, while the woolen maker wants his loom to turn out a material that will readily adopt a great variety of finishes.

Burling

The first finishing operation, which applies also to worsteds, is the examination of the piece for imperfections and the removing of them by

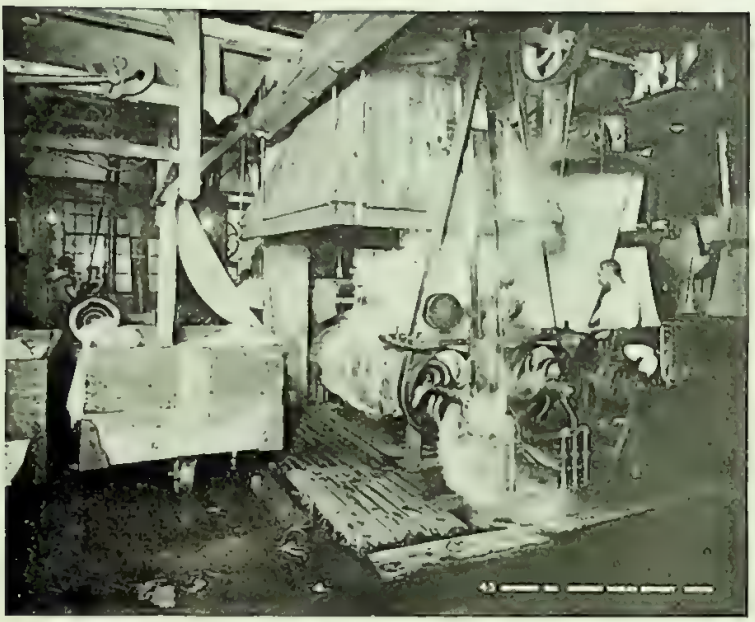


Fulling

hand. The piece is then scoured to get rid of dirt, and, where the finish is complicated, this may be repeated several times.

Fulling, the next and very important process, consists in passing the material through closed or partially enclosed boxes, in which the cloth is run through soap solutions and then forced through rollers. The result of fulling is to shrink the material and give more body to it. It is chiefly in order to be able to do this that the maker of woolens wants the fibres in his yarn to lie criss-cross, so that in the fulling mill their serrated edges will felt and interlock with each other. The amount of fulling done depends upon the shrinkage desired. It is possible to reduce the size of the cloth by half in this process. Some worsteds are slightly fulled, but in their case it simply serves to add a little body to the cloth,

Fulling

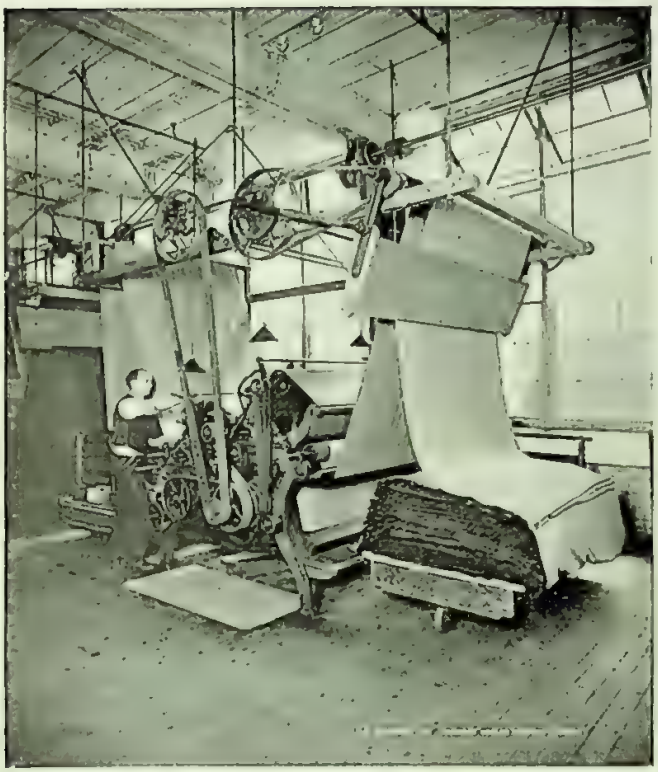


Steaming

without in any way sacrificing the design of the weaving. Long before the invention of even the earliest automatic textile machinery there were great numbers of water-driven fulling mills, in which the woolen cloth was pounded in fuller's earth by wooden hammers. In those days the cloth was felted into a stiff thick mass which would resist wear almost indefinitely, but which would hardly adapt itself to the requirements of modern tailoring.

Raising

The fulled piece is next made to revolve on a large drum set with teazle-heads. The object of this procedure is to open out the fibres, and the process is known as raising. In worsteds and fancy woolens, such as trouserings, raising is really nothing more than the brushing up of the loose fibres so that they may be cropped off, much as grass is cut on a lawn. This will of course have the effect of showing up the weave very plainly. In most woolens, however, the cloth is raised wet, and the teazle motion is more violent, so that the entire surface is covered with a thick nap of brushed up fibres which entirely conceal the weave. This is often very desirable where coarse backing threads are to be hidden, or where,



Cropping

for other reasons, a thick nap is desired, as for instance in rough overcoatings. There may be several raisings and croppings, between which the material is boiled and pressed, all depending on the character of the face that is desired. In some cloths the finishing processes are exceedingly complicated, particularly where a smooth finish such as doeskin is sought. The variety of finishes is infinite and new ones are constantly being invented, many of which are closely guarded trade secrets. In most cases pressing completes the process.

Cropping

Pressing

We have now followed both the combing and the clothing wools through the process of manufacture into worsted and woolen yarns and cloths. Again, let us emphasize that the relative amount of space devoted here to the two industries is governed, not by their comparative import-

ance, but by what appeared to be the most concise method of approach. Many details, which loom up as tremendous problems to the manufacturer, have necessarily been treated here with scant respect, and others have not even been mentioned.

3. Mohair and Alpaca

There are two materials upon which we have not touched at all, although they are generally included in wool manufacture. Mohair is the hair of the Angora goat, and has many characteristics of both hair and wool. These animals are native to Asia Minor, but are now extensively raised in other parts of the world, notably in Africa and in this country. The hair averages about four inches in length, although it frequently grows much longer, is very smooth and fine, has considerable tensile strength, low elasticity, and practically no felting property. It is used primarily in the manufacture of plush, such as is used in railroad carriages, and makes very durable material. It is also woven into Palm Beach cloth, or mixed with worsted or cotton yarns in such fabrics as automobile tops.

Mohair

Alpaca is a similar fibre, obtained from an animal native to Bolivia and Peru. The fibre is finer than mohair, and a little more like wool. It comes in three natural colors; white, brown, and black, all of which are found on the same fleece. Alpaca is both light and soft, and therefore lends itself admirably to the manufacture of thin linings.

Alpaca

4. Knitting and Felt Manufacture

Whereas most wool yarn is woven into cloth, there is also the knitting process, in which the individual threads are interlaced into a regular fabric without warp and weft structure. The work is performed on a sort of loom, called the stockinette frame, upon which the yarns are arranged in parallel order and uniform distances apart. The actual knitting closely resembles hand knitting, and is done entirely by automatic mechanism. A machine of this sort is capable of turning out a great length of material in a short time, and the fabric has the fine ribbed character seen in ordinary knitted goods. The article is soft, full, and elastic, but lacks the strength and firmness of woven fabrics. Stockinette cloths, sweaters, some underwear, and hosiery are products of the knitting machine, and the knitting mills are important consumers of noils and low-grade wools.

Stockinette Frame

Besides being made into yarn, and woven or knit into goods, wool is also compressed into felts of various kinds. Space unfortunately is lacking for the consideration of this subject here, although a considerable quantity of wool goes into felt manufacture.

Felt

CHAPTER IV

THE ECONOMIC ASPECT

1. Financial Risks

Bearing in mind the industrial structure we have just outlined, it might be well for us to glance briefly at its financial scaffolding. From the banker's point of view there are many features which are distinctive of the wool trade, and which exercise an important bearing upon the judgment of a credit risk.

Sheep Banks

To begin with the grower, we find here that in many instances the large raisers of sheep have built up their own banks. In Texas, for instance, there are a considerable number of banks whose chief business consists in financing the wool clips of their sections. On the other extreme we have the small grower of the East, who is frequently at the mercy of the local storekeeper. Where wool growing is practised on a large scale in this country the tendency is more and more to reduce the business to a scientifically standardized scale, in such a manner as is prevalent in Australia. The more this is done the more independent the grower becomes, and the easier it is for a bank to determine the strength of the individual risk. The sheep raiser has of course one primary asset, his flocks; and if he is compelled to borrow, the security behind his note rests upon his sheep. In making a loan to a sheep man a bank has to consider not only the market value of the animals, but the conditions under which they are being raised. Sheep are affected by droughts, for instance, and many flocks have been ravaged by predatory animals, or decimated by disease. Any one of these contingencies may at any moment destroy or depreciate the bank's collateral, and for this reason borrowing of this sort is confined very largely to banks situated in sheep-growing sections which specialize in this form of loan.

Sheep Risks

Grower's Cost

It would be of great interest to figure the average cost of production per pound of wool to the grower, but, with the varying conditions encountered in different parts of the country and with sundry breeds, an accurate estimate can hardly be arrived at. Even the cost of shearing is variously figured from ten to nearly thirty cents. Generally speaking, however, the grower needs very little financial assistance, because he is able to sell his entire clip for cash. The buyers representing merchants —or in a few cases, mills—are prepared to pay cash for their wool, and in some cases where they feel sure of a rising market, often go so far as to buy the wool on the sheep's back before it is shorn. Provided the grower knows something about wool, and the existing demand, there is no reason why, from the proceeds of one clip, he should not be able to meet his costs up to the time of the next shearing.

The Merchant

The merchant is up against a very different proposition. As we have seen, he buys for cash, and not only sells on credit, but carries a large proportion of what he buys for several months, before he can dispose of it. There are so many kinds of wool merchants that it is almost impossible to make any general observations. One merchant, for example, may specialize entirely in domestic wools; in that case he would do all his buying in the spring months and would gradually dispose of his material, having first graded it, during the remainder of the year. Another house might do the bulk of its business in South American wools, which would mean a fall purchasing season. Still another would handle both domestic and South American, and a fourth might import from all parts of the world, so that buying and selling would be going on continuously and at the same time throughout the year. The credit requirements of the first two houses would be an easier demand upon the bank than those of the latter, but in all cases the judging of the risk involves certain primary considerations, each of which really necessitates the close study of the individual case.

Credit Risks

A wool merchant's business is largely based on his estimate of the future. There are no "future" markets for wool as there are for cotton and silk, and the wool dealer cannot therefore protect himself by hedging. Were it not for the fact that he assumes a risk which neither the grower nor, in most cases, the manufacturer is able to take, he could not maintain his position as the middleman. The merchant's buyer must, as we have seen, be able to judge the amount of shrinkage within a very small fraction, he must know the demand for each quality of wool so that he may be sure not to pay more than he can sell for, and, what is more, he must be able to forecast the future with a certain amount of accuracy in order to make his profit. Furthermore, the merchant must be constantly on his guard against doing more business than his capital warrants, while at the same time, unless he makes every dollar work, his business will in normal times fail to show him a profit.

Merchant Manufacturers

Some wool dealers have become considerably more than middlemen, and have gone quite extensively into the first stages of manufacture. This is particularly true of some of the large houses which of recent years have established top manufacturing departments, and which therefore sell a large proportion of their goods not as raw wool but as tops and noil.

Brokers

Although the dealers do the bulk of the commission work in consignment sales, there are a great number of brokers whose function is primarily the buying and selling for account of others. These houses usually operate with a limited capital, and are not extensive seekers of credit.

So far as the manufacturers, or mills of various sorts, are concerned, there is one striking difference about the paper of woolen and worsted mills as against cotton mill notes which appear in the open market; cotton mill paper, except in the case of the strongest mills, usually bears the endorsement of the commission house which sells the mill's product, but this is not as a rule the case with woolen and worsted mill paper. The reason is that a large number of the wool manufacturing establishments sell direct to wholesalers and jobbers, and have no close affiliation with a selling-house. *Mills*

Trade terms vary a good deal. Raw wool is almost invariably sold for cash by the grower. Dealers make various terms to mills, the most usual being 1% ten days, sixty days net. The terms on which mills sell to jobbers also have a wide range; some sell thirty days net, some 10% thirty days, others 7% four months. *Trade Terms*

2. Demand and Supply

Sheep raising is, as we have seen, chiefly carried on on the borderlines of civilization. As civilized life encroaches upon the pasture lands the flocks are driven gradually further and further into hitherto uninhabitated regions. The population of the world is steadily increasing, and the available grazing acres are constantly being reduced as the world becomes more thickly populated. Also, as the population increases, the demand for clothing and food increases, so that, on the face of it, it would seem that the production of wool would decrease while the demand grew constantly larger. In a measure this is true: but there are several factors which tend to arrest this Malthusian spectre. In the first place, there are still vast areas of desert land which can be reclaimed for grazing purposes. In the second place the growing of wool in most countries is as yet practiced on a very crude and consequently uneconomical scale. And, finally, the use of shoddy and wool regained from rags, has only begun to be developed. Nor is it true that sheep must necessarily be raised in uncultivated regions; England, with her closely settled soil, supports about three-fifths as many sheep as the United States, on an area of only 121,377 square miles, as against the 3,026,789 square miles in this country.

The world's total output of wool in 1921 is estimated at three billion, three million pounds, as against two billion, eight hundred and ninety-four million pounds in 1918. The production of the 1921 crop was divided as follows: Europe 899 million pounds, Australia 718 million pounds, South America 592 million pounds, Asia 327 million pounds, North America 298 million pounds, Africa 169 million pounds.

The following table will show the amount of wool produced and imported in the United States between the years of 1897 and 1922:

WOOL PRODUCT OF THE UNITED STATES

U. S. Product

Year	Pounds	Year	Pounds.
1897	259,153,251	1910	321,362,750
1898	266,720,684	1911	318,547,900
1899	272,191,330	1912	304,043,400
1900	288,636,621	1913	296,175,300
1901	302,502,382	1914	290,192,000
1902	316,341,032	1915	288,777,000
1903	287,450,000	1916	288,498,600
1904	291,783,032	1917	285,573,000
1905	295,488,438	1918	299,921,000
1906	298,715,130	1919	298,258,000
1907	298,294,750	1920	277,905,000
1908	311,138,321	1921	273,546,000
1909	328,110,749	1922	261,095,000

IMPORTS OF WOOL INTO THE UNITED STATES

U. S. Imports

Year	Pounds	Year	Pounds.
1897	350,852,026	1910	263,928,232
1898	132,795,302	1911	137,647,641
1899	76,736,209	1912	193,400,713
1900	155,918,455	1913	195,293,255
1901	103,583,505	1914	247,648,869
1902	166,576,966	1915	308,083,429
1903	177,137,796	1916	534,828,022
1904	173,742,834	1917	372,372,218
1905	249,135,746	1918	422,414,985
1906	201,688,668	1919	414,506,891
1907	203,847,545	1920	419,394,201
1908	125,980,524	1921	314,624,288
1909	266,409,304	1922	250,840,752

THE INTERNATIONAL ACCEPTANCE BANK, INC. AND THE WOOL TRADE

The International Acceptance Bank, Inc., opens commercial letters of credit in South America, Australia, and South Africa for the importation of raw Wool. It is particularly well equipped to handle this business because of its intimate connection with The First National Bank of Boston, which is not only the leading wool bank of the country, but also maintains a branch in Buenos Aires. The First National Bank of Boston is one of the most important stockholders of The International Acceptance Bank, Inc.

By reason of its having as shareholders Messrs. N. M. Rothschild & Sons and The National Provincial Bank Ltd., London, as well as many other correspondents in that city, The International Acceptance Bank, Inc., is able to finance imports of wool by means of Sterling credits as well as through its own Dollar facilities.

PART THREE

SILK

By
Benjamin Strong, Jr.
of the
International Acceptance Bank, Inc.

Photographs by courtesy of
William Skinner & Sons and
the Keystone View Co.

Picking Mulberry Leaves

CHAPTER I

THE RAW MATERIAL

1. History

Early Sericulture

Silk owes its position as one of the three leading textiles to its qualities of strength, elasticity and beauty—in which respects it surpasses all other fabrics. Its production dates far into antiquity; for centuries China was the seat of the industry, guarding the secret methods and processes with the utmost care. During the sixth and seventh centuries A. D. the secret began to leak out and sericulture gradually found root in the Near East and the Levant, whence it spread to Greece, Italy, France and Spain. Japan also took it up and developed it to a very high point.

Industry in America

Attempts to establish the industry in America have been generally unsuccessful, high costs precluding the possibility of competing with foreign conditions. In addition, the raising of raw silk has been built up principally in countries where there is a system of home industry—a social and industrial system never developed in the United States. However, although America has never been a factor in the producing of the raw material, it has risen to a place of utmost importance in the manufacture of the finished textile. Immense quantities of raw silk are imported from abroad—principally Japan, Italy, and China—and its conversion into the finished products constitutes a most important part of our industry.

2. The Silk Worm

Names and Types of Silk Worms

The textile fibre known as silk is a filament secreted by one of two general types of moth larvæ—the cultivated and the wild. The largest proportion is, of course, made up of the former, produced by the worm known as the *Bombyx mori*, while the most common type of wild silk worm is called the Tussah. The name *Bombyx mori* comes from the name of the family to which the silk worm belongs: the *Bombycidoe* (spinners), and *mori*, from the *morus multicaulis* or mulberry tree, on the leaves of which it feeds. The species *Sericaria mori*, or silk worm of the mulberry, belongs to the generic class of *Lepidoptera* or scaly-winged insects.

Bombyx Mori

The *Bombyx mori*, with which we are chiefly concerned, is divided into other groups according to the cycle of reproduction. The annuals reproduce once a year, and sixty per cent of the silk worms belong to

Full Grown Worms

this class. The bivoltines reproduce twice a year, and the polyvoltines, several times during the year, the first crop being the best.

The study and development of the various phases through which the silk worm passes, leading up to its production of the actual filament, have been a subject of intense research in many parts of the world for a great number of centuries. The present silk worm is nothing more than a highly specialized product of a long train of artificial cultivation.

Stages of Growth

The cultivated silk worm passes through four changes in its life of two months, i. e., egg, larva, chrysalis (or pupa), and adult—a cream-white moth which is about one inch in length. The moths live only a few days, during which mating takes place, and the female lays several hundred eggs; after about six months these eggs hatch into worms. The latter pass through what are known as four "molts," or shedding of the skin, before the worm matures, spins its cocoon, becomes a chrysalis, and finally emerges as a moth. This, very briefly, is the life history of the silk worm.

3. Modern Sericulture

Silk raising, or sericulture, has been a leading industry in Japan and China for a great many years, while the Near East and such countries

Cocoonery

Countries Producing Raw Silk

as France and Italy have also played a part in the industry—but to a lesser degree. A great deal of this work, particularly in Japan and China, has been carried on as a home industry, but with the growth of modern business methods more and more of the silk raising has come into the hands of companies operating on a highly scientific basis.

Japanese Supervision

After many years of experience and experimentation the breeding and care of the silk worm has been put on a very technical and closely regulated schedule that minimizes the chances of loss by waste or the spread of disease. In Japan the industry has been encouraged and fostered by the Government: a special division of the administration is devoted to its attention, and numerous organizations and associations conduct experimental stations for research and study. In fact since about the middle of the 19th century everything possible has been done to foster this highly profitable branch of the country's industry.

Modern Methods of Cultivation

The merest outline of the modern methods of cultivation will show how highly they have been developed. To begin with, the eggs are placed on sheets of paper or muslin directly after they are laid. These sheets are hung for a few days in a damp atmosphere, and then placed in cold storage for about six months, the period of cold being advantageous for later hatching, which is done by heat.

Hatching the Eggs

Growth of the Worms

After hatching, the worm sheds its skin four times. The periods between the "molts," or ages, vary with different silk worms, but the total process takes about a month. Worms of different ages are always kept separate, being held on large cloth trays which are carried in tiers along the walls of the rearing rooms. The cocooneries where best results are obtained are quiet, spacious, well-ventilated rooms where an even temperature can be maintained. Each worm is kept absolutely clean and has plenty of room, as overcrowding brings disease. As a precaution mild fumigation is resorted to from time to time. Heavy odors or smoke of any sort are not allowed, as these are disturbing to the worms.

Feeding the Worms

Nourishment is, of course, a very important item for the growing worms, and the best form of food for the *Bombyx mori* is the leaf of the white mulberry, which must be young, fresh and dry, but never withered. For this purpose mulberry tree raising has become an important by-industry in itself. Three varieties are found, classified according to the time of budding—early, medium and late. The leaves, therefore, can be found in the correct condition for the various stages in the growth of the worm. The late budding trees are cultivated in more abundance, as the worms are larger at that time and consume more leaves. The soil in which the trees grow is important, as it has been found that one which is rich in certain minerals provides leaves that keep the worms in better physical condition. A cold winter followed by a warm spring develops the leaves well, and the condition of the leaves is one of the most important factors in the whole process.

The Mulberry Tree

Early Development

Careful selection of the eggs is another matter of prime importance. When the leaves are almost ready, the eggs are brought out of cold storage and subjected to heat for about a month before they hatch out. When the worm hatches it is about the diameter of a hair and less than three-fourths of an inch long. It gnaws a hole through the end of the egg from which it issues. Nourishment at first is taken by sucking the sap of the leaves, which are at this stage chopped into fine pieces; later the leaves are consumed without the necessity of their being chopped up.

Spinning the Cocoon

The development is very rapid, the worms consuming their own weight daily. During this period, as has been stated, they shed their skins four times, and after the fourth molt—about one month after hatching—they have assumed their full size. From then on hunger lessens, restlessness grows, and the lifting of the fore part of the body indicates the desire to climb and spin cocoons. For this purpose brush and twigs are provided in the trays, to which the worms attach themselves and begin the spinning process. The silk thread is expelled in a semi-liquid form from two openings underneath the mouth, hardening as it comes in contact with the air. The first threads issued are coarse and rough, having the necessary strength to serve as supports and guys

Worms Feeding

for the cocoon. Gradually the worm is enclosed in the cocoon after three days of continuous spinning, during one of which it is visible and then slowly disappears, though it can be heard working inside.

The worm wastes away as its silk glands are exhausted, and becomes a chrysalis, from which the moth escapes after fifteen to twenty days.

A Nest of Cocoons

Cocoons for Breeding

Cocoons to be used for silk manufacture must be submitted to heat soon after they are completed, in order to kill the chrysalis and prevent it from forcing its way out, thus breaking the fibres. A certain proportion of the cocoons of each crop, however, is allowed to go through the natural process, for reproductive purposes. There is an active market in these breeding cocoons, particularly in Japan and China, and a large quantity are exported annually to Europe and the Near East.

Construction of the Silk Thread

The female cocoon is oval and the male cocoon is peanut shaped. The silk itself consists of two parts: fibroin (the silk fibre) and sericin (the gum). The thread is made up of two strands of fibre held together by the gum, and the length of thread in a single cocoon varies from three hundred to fourteen hundred yards. The cocoons are white, yellowish, or greenish, but after the boiling process the color of the *Bombyx mori* silk is pure white.

Japanese Cocoon Market

The preceding description is concerned more particularly with the latter type, from which the largest proportion of the world's silk supply is derived, but in a general way it applies to the other types also. The most important of these are the Tussah silk of India and China and the Japanese wild silk. The products are coarser and harsher than those of the *Bombyx mori,* and the natural color is brown.

Tussah and Wild Silk

A Japanese Filature

CHAPTER II

REELING

1. History of the Filature

Early Reeling and Twisting

The next step in the production of silk is called reeling, and for this purpose the modern filature has been developed. The actual existence of reeling machines is by no means modern, however, for it is a well-known fact that the Chinese knew how to use raw silk as far back as 5000 years ago. Old prints dating back 3000 years show that the hand "reelers" then in use differed little in principle from the highly developed filatures of today. Although China knew how to reel and twist silk for several thousand years, it was only in the third, fourth, and fifth centuries A. D. that other countries, such as Japan and Eastern Europe, took it up. The first filatures were, of course, extremely simple, operated entirely by hand, and produced a very coarse thread. Although a little progress was made during the Middle Ages, the turning point came in 1750 when Vaucanson, a French engineer, invented the first real filature —which combined several reelers, giving the whole process more speed and turning out a product of considerably better quality. This marked the beginning of Europe's interest in what had so long been an exclu-

Vaucanson's Filature

The Reeling Basins

sively Oriental industry, and from then on the French, Italians and Spanish in particular took up the study of sericulture and the reeling and manufacturing process. The result was to put the industry on a scientific basis which it had never reached in the East. *Silk Manufacture in Europe*

2. Preparing to Reel

The reeling process is the first step in which machinery plays an important part. When the cocoons are ready they must first be submitted to the "stoving" process, or stifling, in which they are exposed to heat sufficient to kill the chrysalis inside. This is followed by further drying, after which the cocoons are shipped in bags to the filatures and may be kept indefinitely without injuring the filament. *"Stoving"*

"Beating"

As a preliminary to reeling, the cocoons are immersed in boiling water to soften the gum that holds the fibre together. While in the water they are brushed with a coarse brush to remove the heavy outer strands of the cocoon—a process called "beating." These outer strands are usually too harsh and broken to be reeled, but are afterwards utilized as so-called waste which is used for spun-silk manufacture.* This applies also to the innermost layers of the cocoon. About one-half of the thread on a cocoon actually finds its way into thrown silk. The remainder is "waste." When, by brushing, the true threads are reached it is possible to start reeling, and barring occasional breaks these threads are continuous all the way down to the chrysalis.

Waste Material

*See Chapter IV. 2.

3. Modern Reeling Methods

While being reeled the cocoons are floated in basins of very hot water, each basin feeding a reeling machine. A single cocoon strand is too fine to use commercially, so several are taken at a time, varying from three to seven or eight according to the size of thread desired. The size used in this country most extensively is known as 13/15 deniers and is reeled from six or seven cocoons. During the reeling the water is kept at about 60° C., but if the cocoons are very dry a higher temperature is required. A heavy smoke issues from the basins and not only humidifies the room but also penetrates the silk, rendering it very gummy and hard. This is overcome by the use of steam-heated tubes running over and around the machines.

Reeling Basins

Each reeling machine and basin is in charge of a girl who is responsible for its operation and for the reeling of thread of correct size. She must keep careful watch that the filament comes off the cocoons steadily and that all breaks are immediately taken care of, exhausted cocoons being replaced by new ones at the proper time. In many filatures each girl is charged with so many cocoons and must turn in a proportionate amount of reeled silk at the end of the day.

Twisting

The twisting operation is an important part of the reeling process, for the raw silk threads, being composed of parallel cocoon filaments, cohering only by their natural gum, would, unless twisted, mat up and become unworkable. Various methods are used to obtain this torque, the general idea in each case being to run the separate cocoon threads through small rings or eyes and then unite them in one thread large enough to reel. In spite of the many mechanical devices and improvements brought out in the last few years, the success of the reeling operation still is dependent on the reeling girl's ability and care. It is particularly important that she be able to judge the number of cocoons

Human Element

Rereeling Room

of a certain size and texture needed to make a thread of the required denier.

Testing the Skeins

The raw silk is reeled on travellers in hanks known as skeins and varying from 50 to 100 grams in weight, which are taken off by the reeling girl and the ends of the thread tied up to facilitate the work at the mill. Before leaving the filature it is also subjected to critical tests and examinations for size, winding, cleanliness, irregularities, etc. The color of raw silk as it comes off the cocoon and is reeled into skeins is either white or yellow, though some sorts have a brownish or greenish tinge. Tussah silks have a brownish-yellow color. The coloring matter in the cultivated silks is only in the gum and boils out with it, but the color in the tussah is in the fibre, rendering it very difficult to bleach.

Color of Raw Silk

"Books" of Raw Silk Skeins

Tussah, or wild silk, is not generally reeled by the wet reel process, as the cocoons are apt to be closed up at each end by gum. In China this gum is softened by burying the cocoons in manure instead of immersing

them in hot water. This is known as dry reeling. It very often happens that the tussah cocoons are unfit for reeling, due to being pierced or tangled. Silk from these imperfect cocoons is again classed as "waste," along with the frisons, or outside and inmost layers of the cultivated cocoons, which, as has been stated, are used to make spun silk. In this country waste silk is often called schappe, although strictly speaking this name should only be applied to waste silk degummed by the French process of fermentation.

Reeling Wild Silk

Waste Silk

The raw silk, having been reeled and twisted into skeins, is next marked and tied together in bundles of skeins known as "books" each bearing the mark or "chop" of its grade. These are packed in bales for shipment, the weight of the bales varying in different countries. In Japan and China they are called picul bales and weigh 133 1/3 pounds. Italian silks, on the other hand, are packed in shipping bales of about 200 pounds.

Baling

Picul Bale

4. Sources of Raw Silk

Of the countries producing raw silk, Japan and China occupy the leading positions by a large margin, the former contributing roughly one half of the world's supply, and the latter about one third. Italy ranks a poor third with about one tenth, and France, the Near East, India, Spain and the Balkans contribute the balance.

Although the greater part of the raw silk produced in the various countries is exported for manufacture abroad, a certain percentage is retained for home spinning and weaving. It is estimated that about 65 per cent of the Japanese output is exported, approximately 90 per cent. of which goes to the United States.

Japan

In China over one half of the output is held for domestic consumption, the remainder being divided about equally between Europe and America.

China

The Italian raw silk—a very high quality product—finds its largest market in France, principally in the city of Lyons, the silk center of Europe.

Italy

CHAPTER III

MARKETING RAW SILK

1. Marketing Methods

The principal raw silk markets of the world are Yokohama, Lyons, New York, Milan and Canton. Of these, Yokohama is probably the larg-

Principal Markets

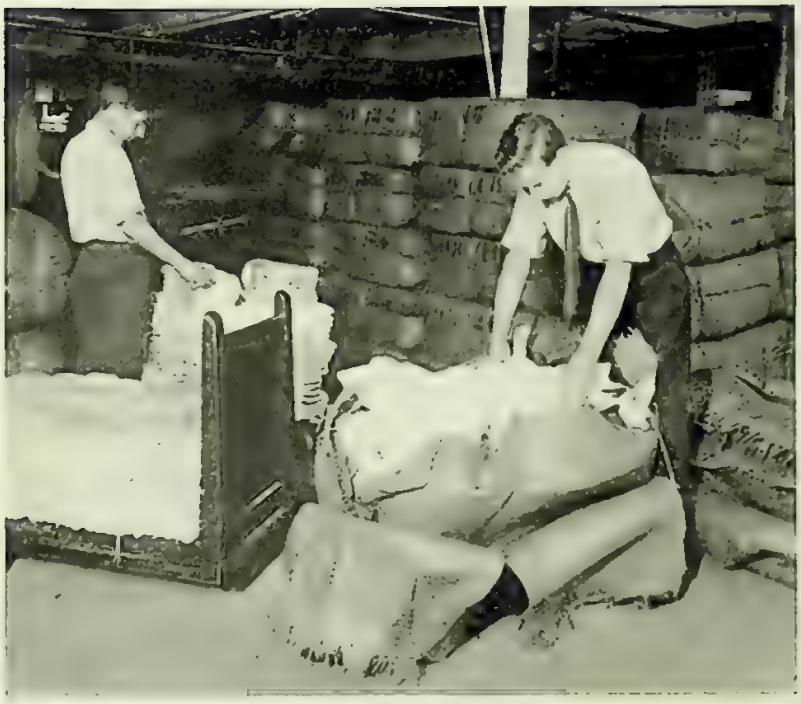
Raw Silk Production, Including Tussah Silk

Seasons 1917-1918 to 1922-1923

Crops in Pounds	1922-1923 Pounds	1921-1922 Pounds	1920-1921 Pounds	1919-1920 Pounds	1918-1919 Pounds	1917-1918 Pounds
Europe	8,841,000	7,628,000	8,058,000	4,927,000	6,978,000	7,154,000
Viz:						
Italy	8,234,000	7,066,000	7,330,000	4,045,000	5,942,000	6,217,000
France	437,000	430,000	551,000	397,000	540,000	452,000
Austria	.....	.....	.....	‡331,000	‡331,000	‡331,000
Spain	170,000	132,000	177,000	154,000	165,000	154,000
Levant	1,543,000	1,213,000	1,654,000	‡2,293,000	‡2,293,000	‡2,293,000
Asia: Total Quantity Exported*	57,439,000	53,941,000	35,138,500	51,860,000	45,475,000	48,026,000
Viz:						
China, Shanghai	†8,628,000	†6,993,000	†6,518,500	†10,225,000	†9,209,000	†8,563,000
China, Canton	7,050,000	5,735,000	4,210,000	7,093,000	3,704,000	5,170,000
Japan, Yokohama	41,541,000	40,982,000	24,300,000	34,222,000	32,308,000	34,050,000
India	220,000	231,000	110,000	320,000	254,000	243,000
Total, Pounds	67,823,000	62,782,000	44,850,500	59,080,000	54,746,000	54,473,000
Tussah	2,034,000	1,856,000	1,650,000	1,960,000	1,561,000	1,534,000
Grand Total, Pounds	69,857,000	64,638,000	46,500,500	61,040,000	56,307,000	59,007,000

*The production of raw silk in China and India is unknown. The Japan crop is approximately 47,000,000 pounds. †Excludes Tussah silk. ‡In the absence of statistics from Austria and the Levant, 1915 production is used as an estimate.

Courtesy of The Silk Association of America



Unpacking Bales of Raw Silk

est and most important, due to the pre-eminent position of Japan in raw silk production.

Yokohama Silk Exchange

The Yokohama Raw Silk Exchange operates on a basis similar to that of the various cotton exchanges, and transactions are carried on in "futures" as far ahead as five months. The speculative element is very active and its influence is often felt extensively throughout all phases of the industry. On several occasions it has been necessary to close the exchange to avert real disaster after the quotations have been manipulated to an unbelievable extent. During the last few years the Japanese Government and various silk organizations have, by law and regulation, succeeded in improving this situation to a very great degree, and the benefit has been felt throughout the industry.

Conditioned Weight

Raw silk is sold by weight—in Yokohama, by net weight, that is, less wrappings, etc. Of recent years in most countries it has been the custom to deal by conditioned weight, and as a result the conditioning process has become an important side line in the industry.

2. Conditioning

Invoice Weight

Conditioning is desirable principally on account of the fact that raw silk absorbs considerable moisture. A careless buyer may find after delivery that he has purchased more water than he has silk. To avoid this possibility, Asiatic and European markets in particular have adopted the conditioned weight basis—absolute dry weight plus 11 per cent moisture. Quotations are often given on invoice weight, which is conditioned weight plus a 2% margin for variation.

A conditioning house, besides examining for weight, also conducts numerous other tests necessary to conditioned silk. The main factors taken into consideration, besides weight, are size, color, cleanliness, boil-off, winding strength, elasticity, and general uniformity.

Weight

As regards size, the unit is the denier, an ancient French weight equal to .05 gram; the size is measured by the weight in deniers of 450 meters of the thread. As previously stated, the 13/15 denier size is the standard used in the United States, although the larger and smaller grades are dealt in to some extent for special types of products. Size is always given as averaging between certain deniers (such as 13 to 15) as it is impossible to attain absolute accuracy in reeling, and slight variations cannot be avoided, either within the bales or within the skeins themselves.

Color

The color test is concerned merely with uniformity in shade, which makes accurate dyeing possible. The cultivated silks are either pure white or yellow, according to the variety of cocoon from which they are derived.

"Boil off"

The term "boil off" refers to the amount or percentage of gum on the filament. As explained before, the individual strands of fibre adhere together through a gummy substance secreted by the worm. The amount found in the reeled silk varies with different kinds from 10 to 25 per cent by weight—which is brought down to a minimum by the boiling process.

Winding Strength

Winding strength is measured by the breaks that occur in winding. In this country the test is based on the number of breaks occurring in 30 or more skeins wound at the rate of about 120 yards per minute. This test is extremely important since a weak thread can do much to hinder an efficient re-reeling process, inasmuch as each break stops the machine and must be tied by the operator.

3. Grading and Quotations

The question of classification of raw silk for market and the various terms used for its purchase and sale is a complicated one. Standardiza-

tion has been sought after for a good many years and committees both here and abroad have studied the problem on various occasions—but without entirely satisfactory results. The chief source of trouble appears to lie the many types of variation that may occur, not only on account of the great number of qualities required in the product, but also due to the varying conditions under which the silk is produced. In the early days of the industry, when farm production was the chief source of supply, particularly in Japan and China, satisfactory grading was almost an impossibility. However, now that sericulture and reeling has come more and more into the hands of the large companies and filatures, a greater degree of standardization can be reached.

Classification

Difficulties in Grading

The following is an actual example of a recent quotation list in the New York market as it appeared in a commercial paper:—

Quotations

JAPAN

(Ninety Days' Basis, 13-15 Denies)

Kansai	Double Extra Cracks	$6.15 @ $6.20
Kansai	Double Extra "A"	6.05 @ 6.10
Kansai	Double Extra "B"	6.00 @ 6.07
Kansai	Best Extra	5.95 @ 6.02
Kansai	Extra	5.90 @ 5.97
Kansai	Best No. 1 to Extra	5.87 @ 5.95
Kansai	Best No. 1	5.85 @ 5.92
Kansai	No. 1	5.82 @ 5.90
Sinshiu	No. 1	5.77 @ 5.85

CANTON

(Ninety Days' Basis)

King Seng gr. 14-16	$6.40
Favorite—Double Extra 20-22	6.00
Favorite—Double Extra 22-26	5.90

SHANGHAI

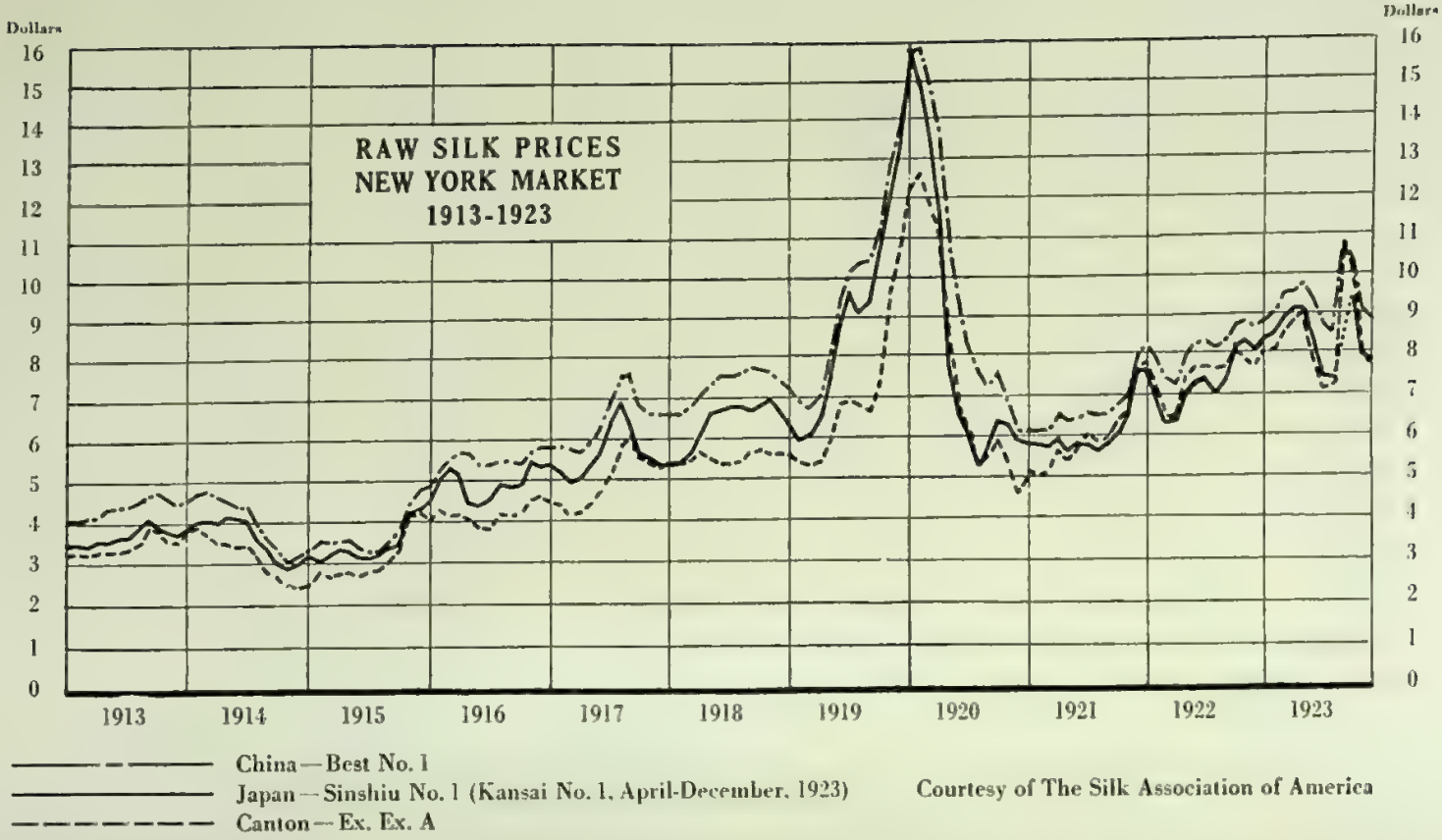
(Ninety Days' Basis)

CHINA STEAM FILATURE

Gold Double Deer, new crop	$7.50
Geranium, new crop	7.25
Comet	6.60
Tsatless Blue Dragon and Flying Horse	5.60
Black Lion, No. 1-2	5.10
Tussah—Best chops	3.90

ITALIAN

Grand Extra Classical	$7.00
Extra Classical	6.80
Best Classical	6.70



Courtesy of The Silk Association of America

In the Japanese classification, Kansai and Sinshiu originally indicated the section of Japan where the silk originated, but of recent years they have come to mean hard or soft natured silks respectively. The "Sinshiu No. 1" is usually considered the standard quotation to use in judging the market trend. *Kansai and Sinshiu*

The Chinese quotations are probably the most difficult to understand since they go almost entirely by "chop"—that is, well-known brands which are marked in some distinctive way, as shown on the above list of quotations. *"Chops"*

CHAPTER IV

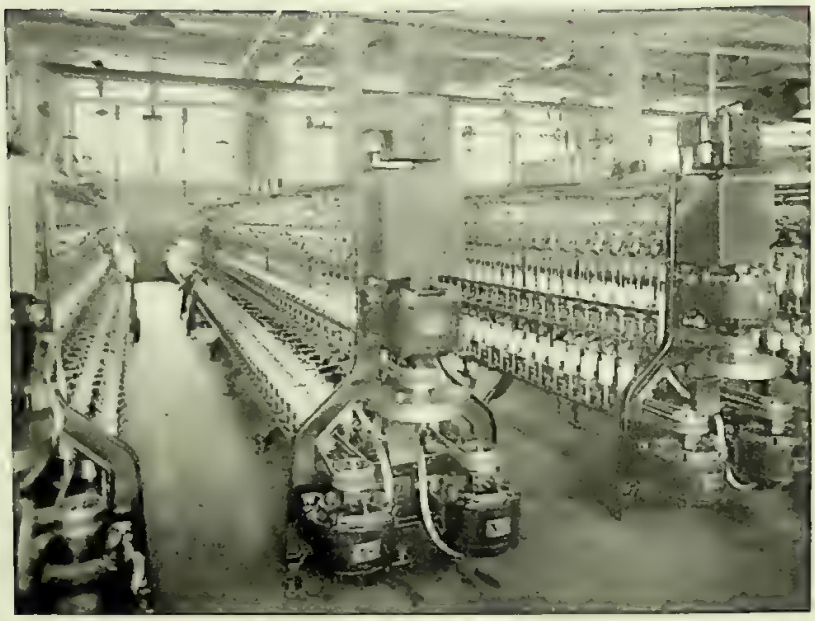
MANUFACTURE OF THROWN AND SPUN SILK

We have covered in the preceding chapters the culture of raw silk, its reeling, and finally its marketing in the countries where it is to be manufactured into the finished textile. We now come to the mechanical phases of the industry, by which raw silk is made first into yarn and then into fabric. Whereas, in the case of cotton and wool, we have seen that yarn is manufactured by various modifications of the spinning process, this is not true in the case of silk. The spinning process is here supplanted by an operation known as "throwing," and is resorted to only in the manufacture of yarn from the various kinds of silk waste.

1. Thrown Silk

The ordinary raw silk, as it comes from the filature and is sold in the market, is composed of from two to eight filaments adhering together by virtue of the natural gum secreted by the worm. This thread is too thin and delicate for many uses and so must be submitted to further twisting and doubling—a process called "throwing." It must be borne in mind, however, that there are several types of fabrics in which raw silk is used without going through the throwing operation. This is usually the case, for example, with the warp threads for crepes, charmeuse, and messaline. *Necessity for Throwing*

Although some of the larger silk mills have their own departments for this process, as a general rule it is done by independent concerns known as "throwsters"—who specialize in this particular operation. Machinery of a very complicated and accurate type is necessary, capable of operating at very high speed. It has been found that the investment called for to equip such a mill is too large in most cases to allow the manufacturers to incorporate this operation in their factories, par- *"Throwsters"*



Throwing Machines

ticularly if it happens that the spindles are not fully employed during the whole of the year.

Organzine and Tram

There are two main classes of thrown silk—organzine and tram—the former has a heavy twist and is used for the warp; while the latter is given only a light twist and is used for filling. Within these two general types there are many special grades, according to the type of material for which they are to be used, such as crepe, chiffon, sewing thread, floss silk, embroidery silk, etc.

Soaking the Raw Silk

The raw silk as it comes to the throwing mill is done up in books of skeins and packed in bales, as described in a previous chapter. The skeins, after being weighed and examined, are first soaked for about twelve hours in warm soapy water, which softens the natural gum, after which they are thoroughly dried. This, of course, reduces the moisture content below the customary 11 per cent, which is later restored by natural absorption.

Winding

The first step in the actual throwing is the winding of the thread on bobbins. The skeins are put on swifts—a light type of reel—and wound

at a very high rate of speed on the proper size of bobbin. It is here that the winding strength of the silk meets its severest test, for constant breaks during the winding involve considerable expense when speed is such an important factor.

The bobbins of silk are next taken to the twister, which combines two or more strands and gives the thread the necessary amount of twist for the special type that is desired. In the case of tram a very light twist is given, about two or three turns to the inch. For organzine the single threads are first given sixteen turns to an inch in one direction, then doubled and twisted fourteen turns in the other direction. *Twisting*

Twisting is the basis of the manufacture of the various kinds of crepe. The filling or tram used is given a very hard twist, about sixty-five turns to the inch—either in right or left-hand direction. These threads are later woven alternately and so produce the crinkled effect. *Crepe*

Thrown silk is classified in a similar way to raw silk, except that usually market quotations on thrown silks mention not only the classification but also the purpose for which it is to be used (tram or organzine), the size in deniers, the number of threads and twists to the inch.

2. Spun Silk

The above processes refer only to throwing of raw silk. In the case of waste, schappe, frisons, etc., an entirely different method must be used, comprising a series of operations very similar to the carding, combing and spinning of wool.* The gum, of which silk waste contains a very large proportion, must first be boiled off in a hot soapy bath or allowed to ferment in vats, the latter method being used more generally in Europe. After degumming, the waste silk is next washed and dried and allowed to absorb the 11 per cent moisture content, as in the case of the thrown silk. This is followed by picking, combing, and dressing to remove any dirt or other foreign matter and to separate the fibres and arrange them in parallel order. *Spinning Waste Silk*

The silk is next separated into short laps, then drawn out into thin slivers by means of drawing frames, and thoroughly combed to make the fibres smooth and uniform. These slivers are finally made suitable for winding on bobbins by being passed through roving frames. Then follows the actual spinning process, which twists the roving into yarn. Different types of yarn are produced by varying the amount of twist and the number of strands used. Single yarn is made by twisting a single strand on itself, while for 2-ply, two yarns are twisted together, and so forth, as in the case of cotton or wool.

*See Part Two, Page 74 to Page 78 for details of spinning.

After being cleaned and examined, the yarn is wound into skeins of about 5 ounces.

Uses of Spun Silk

The principal use of spun silk is in mixed fabrics, in conjunction with wool, cotton, or raw silk, the spun silk thread generally being used as filling rather than warp. The better grades are made into velvet and plush and various types of knit goods. Although high quality spun silk often has the strength and wearing quality of thrown silk, it never can compete with the latter in regard to lustre.

Sizing

Spun silk is described as to size in one of two general ways. In the English system the number of the yarn is the number of hanks of 840 yards weighing a pound, with a second number indicating the ply. Thus, size "20-2" would designate a 2-ply yarn, a pound of which contained 16,800 yards. The French system is more or less on the same principle, the main difference being that the number of the yarn indicates the thousands of metres weighing a kilogram.

3. Marketing Thrown and Spun Silk

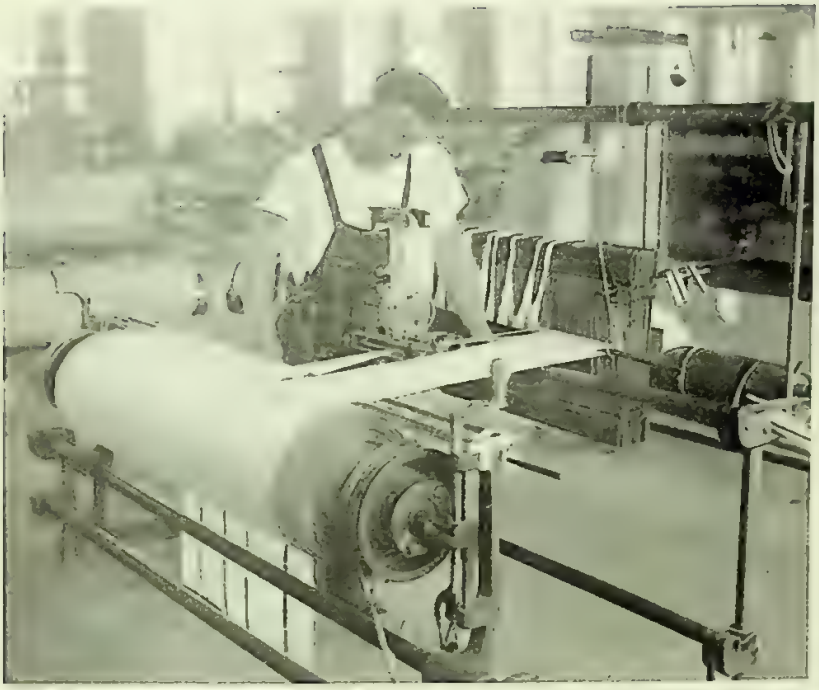
Thrown and spun silk are bought and sold in very much the same way as is raw silk, although the market is not as extensive nor is the volume of trading as large. The following tables of quotations are from a recent silk journal. A comparison with the quotations given in Chapter III will show the appreciation in value of the various gradings through the throwing and spinning processes.

THROWN SILK

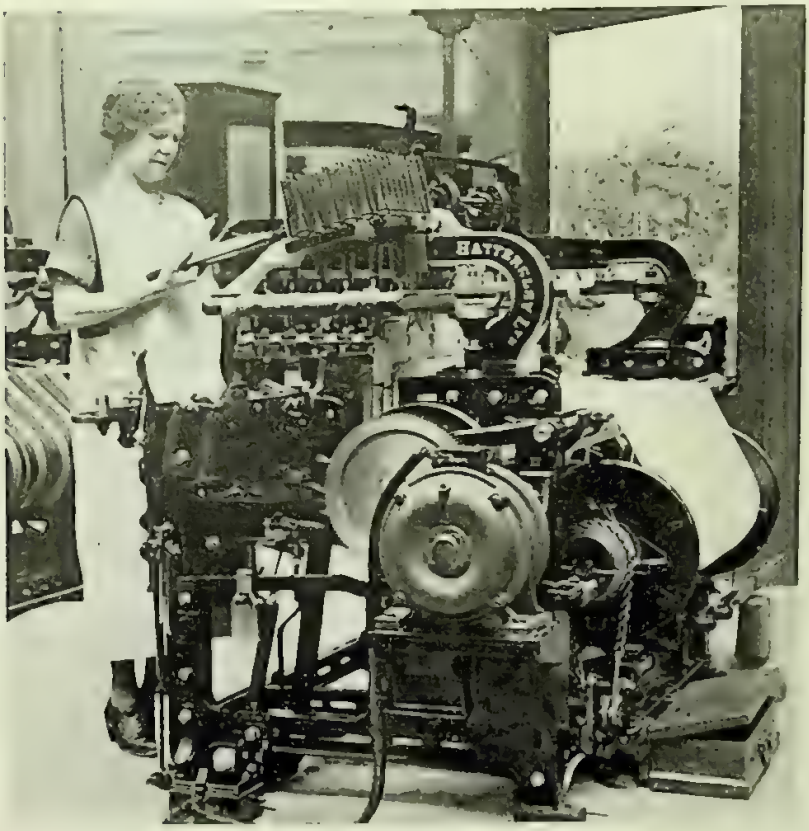
Organzine	
Double Extra Crack	$7.30
Double Extra	7.20
Extra	7.10
Tram	
Extra	$6.85
Best No. 1	6.75
Kansai No. 1	6.70
Japan Crepe Twist, 2 thread, 75 turns	7.80
Japan Crepe Twist, 3 and 4 thread, 60-65 turns	7.25
Canton Crepe Twist, 3 and 4 thread, 60-65 turns	7.20
Hosiery Tram	6.75

SPUN SILK

	2% net 30 days
6/2	$4.25
10/2	4.35
20/2	4.75
30/2	5.15
40/2	5.35
50/2	5.50
60/1	4.45
60/2	5.60



Twisting on New Warp Threads



Modern British Loom

Shown at the British Empire Exposition
Wembley, 1924

Imports

Although far from approaching raw silk, the importations of silk waste to this country reach quite substantial figures, as the following table shows:

	Raw Silk	Waste Silk
1920	30,058,374	9,400,985
1921	45,355,095	6,849,369
1922	50,711,826	7,638,317
1923	49,505,581	12,101,420

(Courtesy of Silk Association of America)

CHAPTER V

WEAVING AND FINISHING

1. Weaving

The manufacture of thrown and spun silk into the finished material, whether by weaving or knitting, varies with the different types of fabric desired. But the several processes are based on the same general principle and are very similar to those used for cotton and wool. To avoid repetition we would refer to Pages twenty-six to twenty-nine and Pages thirty-one to thirty-five, where full descriptions will be found.

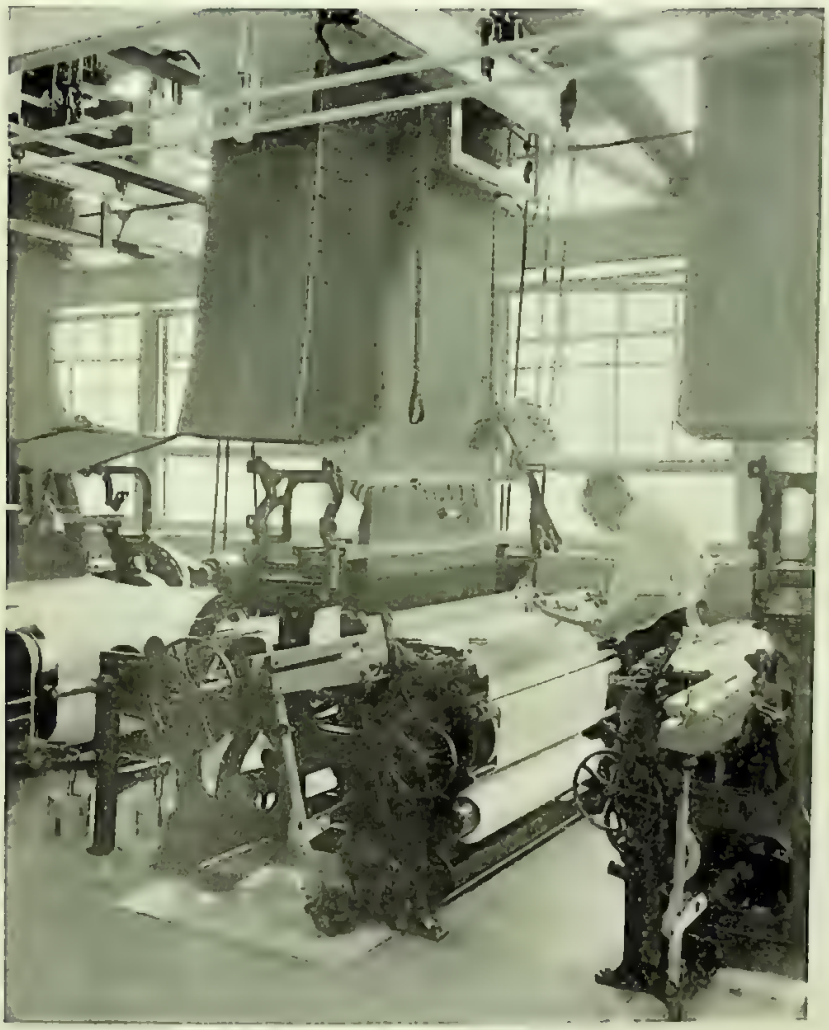
2. Finishing

The first step in the finishing of fabrics is dyeing—unless it has already been done before weaving. A considerable proportion of silk is dyed in skein or yarn form before weaving, but in either case the methods of dyeing are practically the same. Preparatory to dyeing it is necessary to boil off the natural gum by means of hot soap baths. If the silk is to be dyed in dark colors a considerable amount of the gum is allowed to remain. Such silk is known as souple silk and is used principally for filling. If all the gum has been removed, it is called bright silk.

Boiling Off

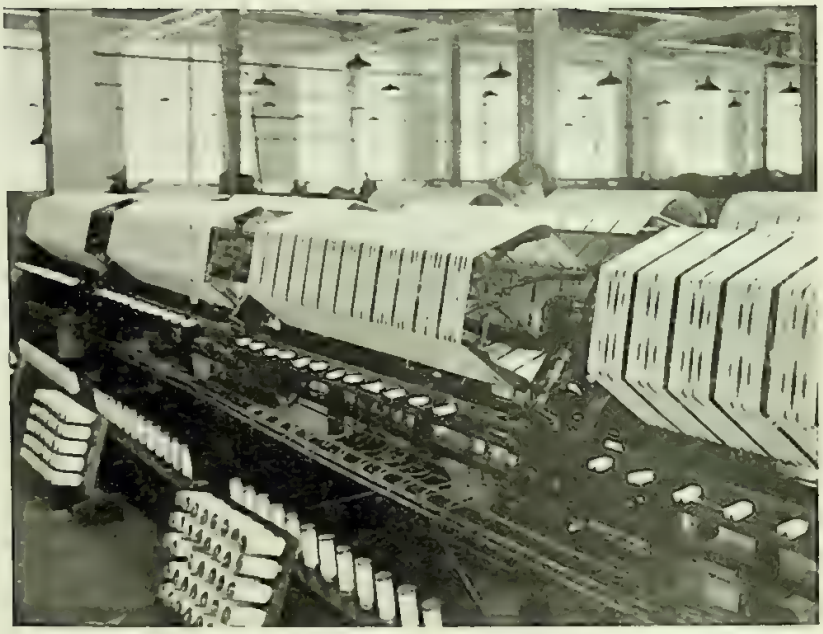
All silk, after boiling off, should be nearly pure white. Raw silk, as mentioned in a previous chapter, is often bright yellow, but as this color is entirely in the gum, it is lost by boiling off. In the case of uneven coloration in the raw silk, it is necessary to resort to bleaching before dyeing in order to get uniformity in the finished product. This applies particularly to wild silks, such as Tussah, which are bleached by being placed in an air-tight room filled with a chemical preparation, such as sulphur gas or sodium or hydrogen peroxide. A further washing and drying is then necessary before the skeins or goods can be dyed.

Bleaching



Jacquard Loom

There is no standard dye used for silk, some manufacturers preferring one type and others, another. It may be said, however, that as a general rule silk is dyed by the direct method, without the use of an intermediate or mordant agent as in the case of cotton. This is made *Dyeing*



Winding Thrown Silk into Skeins for Dyeing

Mordant Dyes

possible through the natural absorptive powers of silk fibre. Mordant dyes are sometimes used, it is true, salts of tin or iron being employed as the agent; but this method is useful principally when it is desired to weight the silk and restore what was lost in boiling off. As this loss generally amounts to about 20 or 25 per cent and as raw silk is sold by weight, it is easy to see that this, unless recovered in some way, would reduce the manufacturer's profit considerably.

Weighting Silk

The process of weighting silk has been greatly abused, as it is comparatively simple to adulterate it, without discovery, to such an extent that the properties of the fibre are seriously impaired. Weighted silk never has the strength or wearing quality of the unadulterated product. However, a certain amount of weighting—to restore a part of the degumming loss—is generally recognized as legitimate, although the percentage permissible is often a matter for discussion.

Both skein and piece silk are dyed by being immersed in vats containing the hot dye solution. The silk is run over rollers which insure even coloration throughout. After dyeing it is dried, stretched on a tenter

frame and then submitted to dry heat which sets the dye and adds luster to the silk.

Printing

Printing is also used for coloring and pattern effects in very much the same way as for cotton goods. After printing the goods are submitted to a dry steam heat which sets the colors.

Finishing

Beyond dyeing or printing, silk goods require very little finishing other than calendaring by passing through rollers. Some types of fabric require softening and others, hardening—accomplished in a variety of ways too numerous to describe. Many of these are secret processes perfected and patented by individual companies. A multitude of different effects can be obtained by these various treatments of the surface of the goods.

CHAPTER VI

ARTIFICIAL SILK

1. Early Development

Chardonnet

The discovery of what is known as "artificial silk" is generally attributed to a Frenchman, Count Hilaire de Chardonnet, who after many years of research and experimentation, between 1840 and 1890, finally perfected a fibre that possessed the necessary qualities for practical weaving. He introduced his discovery to the public in 1891 at the Paris Exposition, and in addition to winning the "Grand Prix" was also made a knight of the Legion of Honor in recognition of his contribution to science and industry.

Further Development

Since that time others have contributed to the development of the new fibre and discovered other methods of production—all, however, based on the same general principle as the Chardonnet process. Despaisses and Panly, two Frenchmen, and Stearn, Cross and Bevan, Englishmen, are the outstanding names in this work.

2. Various Processes

Use of Cellulose

All the processes that have met with any success are based on the use of cellulose in some form, as a foundation. The two sources that have proved most successful are wood-pulp and cotton and it may be said that the bulk of the artificial silk on the market comes from one or the other of these two raw materials.

Chardonnet Process

The Chardonnet process uses cotton as its base. It is first bleached, then by chemical treatment is changed to nitro-cellulose, which is dissolved in alcohol and ether and thus made ready for "spinning."

Viscose Process

The Viscose process, which has made great strides in recent years, makes use of a pure grade of sulphite wood-pulp. This pulp is in sheet form and is first treated with a solution of caustic soda, then shredded very fine and put through several more chemical treatments, finally being dissolved in water preparatory to the "spinning."

"Spinning"

In both of the above methods the production of the thread is the same. The solution, whether it be based on cotton or wood-pulp, is forced through minute holes and comes out in a thread-like stream, which solidifies when subjected to a setting bath. It is then washed, dryed, and put through processes, such as twisting, reeling, etc., very similar to those which natural silks undergo.

3. Uses of Artificial Silk

The uses of artificial silk are many and are not entirely confined to combinations with other textiles. Of recent years the knitting trade has adopted it extensively, particularly in hosiery, sweater and underwear manufacture. In weaving, it has proven very successful in combination with silk or cotton. Large quantities are used in ribbon, electric cord covering, yarns, threads, etc. It is generally felt that the new fibre does not directly compete with or replace natural silk, but rather occupies its own place in the trade on the same basis as the other textiles.

Growth of the Industry

It has only been during the last fifteen years that artificial silk has been a very important factor commercially, although for a few years before that time, small quantities were produced in Europe. Since about 1910 its use has been steadily growing in this country, the importations from Europe increasing in 1912 from about one and one-half million pounds to nearly three million pounds in 1914. Since 1910 domestic production has also become a factor in the market and numerous factories have been established, the figures for 1923 showing about 33,000,000 pounds output. It is estimated that in 1922 the combined importations and domestic production amounted to around 20,000,000 pounds, about 50% of the total consumption of natural silk for that year.

U. S. Production

The following figures show the production of artificial silk in the United States in 1913 and between 1920 and 1923:

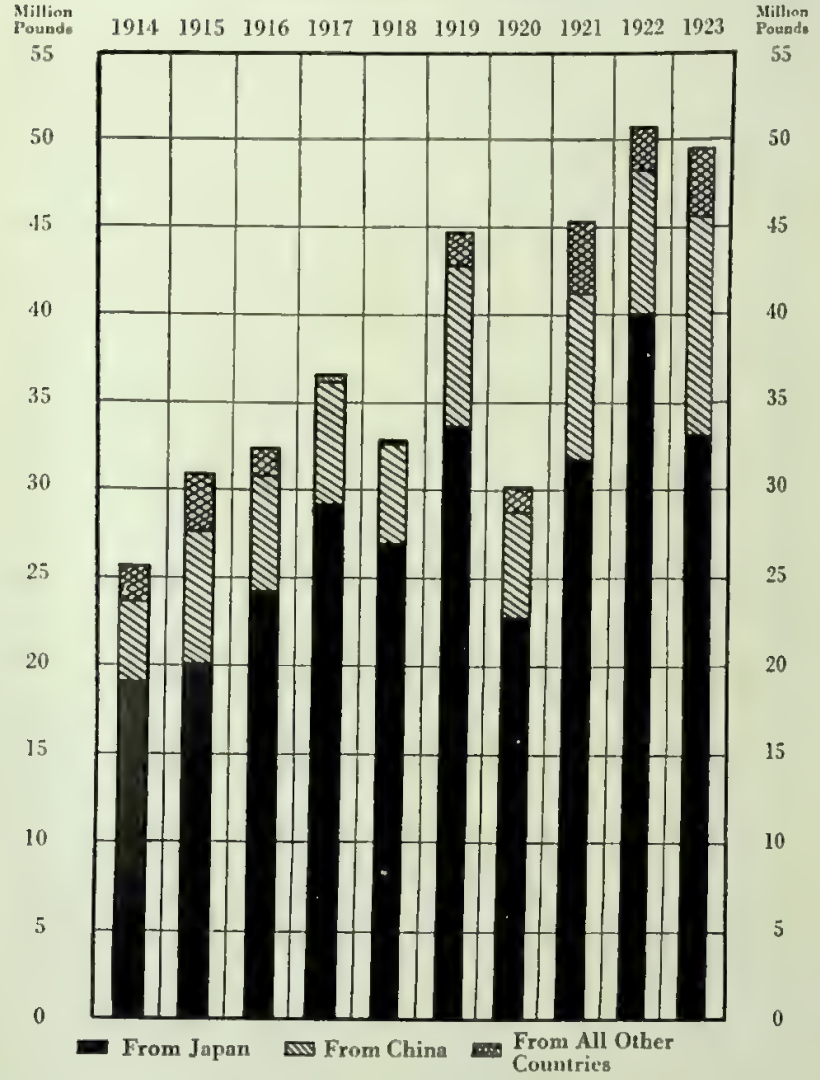
1913	1,566,000	pounds
1920	8,000,000	"
1921	15,000,000	"
1922	24,000,000	"
1923	33,000,000	"

IMPORTS OF RAW SILK

Into The

UNITED STATES OF AMERICA

Calendar Year 1914-1923



Courtesy of The Silk Association of America

THE INTERNATIONAL ACCEPTANCE BANK, INC. AND THE SILK TRADE

THE INTERNATIONAL ACCEPTANCE BANK, INC., finances annually the importation of millions of dollars worth of SILK from China, Japan, and Italy.

THE INTERNATIONAL ACCEPTANCE BANK, INC., can offer exceptional facilities for opening commercial letters of credit in the Far East by reason of its large net-work of correspondents, and particularly because of its close relation to the NETHERLANDS TRADING SOCIETY, with branches throughout the Far East, which is one of its leading shareholders. Through its close relationship with this institution, and with many other Eastern banks, THE INTERNATIONAL ACCEPTANCE BANK, INC., can obtain for its clients a highly efficient service and can give them the benefit of the confidential information which it receives.

The Berkeley Press
Boston